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Relationship Between Cow Type Classification Score and Cow Productivity

John Frey, R. R. Frahm and D. F. Stephens

Story in Brief

The purpose of this study was to determine the relationship between cow type classification score and measures of cow productivity and to determine the accuracy of type classification score for predicting cow productivity, both alone and together with cow weight, cow condition score and information provided by the performance record of a cow's first calf.

Classification and productivity records from 220 Angus cows raised under range conditions were studied. The cows were classified in 1964 and 1965 by official breed association classifiers and performance was measured on their calves produced from 1965 to 1969. Cow productivity was measured by calf performance to weaning.

The correlation coefficients between type classification scores and measures of cow productivity were of low magnitude. A slight negative association was indicated between type classification scores and cow productivity as measured by calf weaning weight. Spring classification scores had virtually no association with cow productivity; however, fall classification scores were negatively correlated with cow productivity as measured by most probable weaning weight for cows 2 and 3 years of age at first classification. Fatter cows tended to receive higher type classification scores but weaned lighter, lower scoring calves. Total type classification score was of little value in predicting future production ability as measured by most probable weaning weight. Although of limited value, a heifer's 18-month adjusted weight was the most accurate estimator of future pro-

In cooperation with Ft. Reno Livestock Research Station, Agricultural Research Service, Animal Science Research Division, USDA.

ducing ability for heifers prior to calving. Weaning weight of the cow's first calf was a more reliable predictor of future producing ability than any of the measurements taken on the cow.

Introduction

Beef cattle breeders have traditionally put some selection pressure on the visual subjective evaluation of an individual's usefulness for a certain purpose. One of the objectives of their breeding programs has been to produce animals of a certain type. The present concept of desirable beef type is generally characterized by abundance of muscling, freedom from excess fat, and adequate size and scale. In practice, type is subjectively determined by visual appraisal of body size and conformation. Breed association type classification programs constitute an attempt to standardize type selection guidelines of cattle for breeding purposes by comparing an individual's type to the breed type ideal.

In addition to type, breeders select breeding stock on the basis of performance in economically important traits. Evidence has strongly indicated that performance should be the first consideration; however, selection pressure for type still continues. In breeding programs designed to improve the level of productivity, it is important to determine the relative attention to give actual performance records and visual appraisal of the animal being evaluated. The proper utilization of these two kinds of information in selecting breeding stock requires an accurate determination of the relationship between type and productivity.

Materials and Methods

The data used in this study were the official type classification scores of 220 purebred Angus cows classified in 1964 and 1965 and the preweaning performance records of 990 Angus calves raised from 1964 to 1969 at the Fort Reno Livestock Research Station. These cattle are part of the four Angus lines involved in a beef cattle selection experiment which has been described by Frahm and Whiteman (1968) and Frahm (1970).

The measure of type used in this investigation was the official breed association type classification score given the cows in the spring and fall of 1964 and 1965. Five official classifiers scored the cattle during the first three classifications and six official classifiers scored the cattle in the fall of 1965. The average of the scores given a cow by all classifiers on the same date was used as the type score for that cow since it should be the most accurate estimate of a cow's true type. The cows either had calved or were about to calve when the spring classification was made,

and the fall classification was made after weaning. The cows were categorized into four age groups: 1, 2, 3 and 4 years and older, based on their age at first classification. Cows in age group 1 were approximately 18 to 20 months of age when first classified.

The score card used to determine type classification score is presented in Table 1. A score of 100 represents the breed ideal for type and the total score given an individual represents the percentage approach to the breed type ideal. The cows were also evaluated for condition or fatness by the official classifiers using a 1 to 5 scale with 1 representing a very thin cow, 3 a cow in average condition, and 5 a very fat cow. The cows were weighed in the winter, in the spring after calving and in the fall after weaning and cow weight at the time of classification was determined as a linear estimate based on the two closest actual weights.

Cow productivity was measured by calf performance to weaning. The method of least squares was used to obtain additive correction factors for adjusting birth weight, 205-day weaning weight, and weaning conformation score for the effects of years, sex of calf and age of dam. These correction factors served to adjust the calf performance records for these known non-genetic sources of variation and thereby placed the calf performance records, and consequently the cow productivity measures, on a more comparable basis. A cow's productivity record consisted of the adjusted birth weights (BW), weaning weights (WW) and weaning conformation scores (WS) of her offspring. In addition, the most probable producing ability (MPPA) of each cow was determined for birth weight

Table 1. Score Card for Cow Type Classification.

Component		Maximum score possible
General Appearance		50
Appearance		30
(Type)	(14)	
(Size)	(10)	
(Quality)	(6)	
Breed Qualities		20
(Feet and legs)	(12)	
(Head and breed character)	(8)	
Beef Character		50
(Shoulder and chest)	(8)	
(Rib and back)	(10)	
(Loin)	(10)	
(Rump)	(10)	
Rear quarters or round	(12)	
Total Score		100

(MPBW), weaning weight (MPWW), and weaning score (MPWS) according to the formula:

$$MPPA = HA + \frac{nr}{1+(n-1)r}(IA-HA)$$

Where HA is the herd average, IA is the individual's average, n is the number of records that the IA is based on and r is the repeatability of the trait.

The repeatability of a trait is the correlation between different performance records of an individual, and it indicates the extent that observed differences between performance records of individual will be repeated in the future. The repeatability estimates used in this study were 0.25, 0.40, and 0.30 for birth weight, weaning weight, and weaning score, respectively.

The cow productivity measures considered in this study were the cow's first performance record as a 2-year-old, the average of all available performance records, and the most probable producing ability measures. A cow's first and average performance records will be denoted by a prefix "1" and "A", respectively. Thus, "1BW" and "ABW" indicates the birth weight of a cow's first calf and the average birth weight of all calves, respectively. Of the productivity measures considered, MPPA is expected to provide the most accurate estimate of an individual's relative genetic potential for productivity. Some of the cows in this study were obtained after they had produced one or more calves. Consequently, data were not available on the first performance record for cows in age groups 3 and 4. There were 119 and 220 cows with first and average performance records, respectively. The number of performance records per cow ranged from one to six, the average being 3.38.

Results and Discussion

Correlation Analyses of Classification Scores and Cow Productivity Measures

The least squares additive correction factors used to adjust birth weight, 205-day weaning weight, and weaning score for the effects of year, sex and age of dam are presented in Table 2. Calf performance records were adjusted to a bull calf out of a mature cow (5 years and older) basis. The means and standard deviations for the classification variables and for cow weight (WT) at classification time are presented in Table 3. The means and standard deviations for the productivity measures are presented in Table 4. The correlation coefficients between

Table 2. Additive Correction Factors For Birth Weight, Weaning Weight and Weaning Score.

Source	Birth Weight, lbs.	Weaning Weight, lbs.	Weaning Score
Year			
64	2.66	5.96	— .30
65	— .34	— 2.69	— .12
66	— 1.79	0.94	0.15
67	— .15	—11.59	— .21
68	— 4.21	—20.09	0.16
69	3.83	27.47	0.32
Sex[1]			
1	0.00	0.00	0.00
2	3.99	35.86	— .14
Dam Age (yrs.)			
2	7.31	60.89	0.76
3	2.86	37.52	0.47
4	1.55	11.91	0.17
≧5	0.00	0.00	0.00

[1] Sex 1 = bulls, sex 2 = heifers.

Table 3. Means and Standard Deviations for First and Average Classification Variables and Cow Weight at Classification Time.

Variable[1]	Number of cows	First classification		Average classification	
		Mean	St. dev.	Mean	St. dev.
APP (30)	220	24.6	1.3	24.3	1.3
BRQL (20)	220	15.6	0.6	15.3	0.7
GAPP (50)	220	40.2	1.7	39.6	1.7
BFCR (50)	220	38.3	1.4	38.1	1.4
TSC (100)	220	78.5	2.9	77.7	3.0
WT (lbs.)	220	875.6	147.6	932.5	140.3

[1] The figure in parenthesis is the maximum score possible for the classification variables.

Tble 4. Means and Standard Deviations for the Cow Productivity Measures.[1]

Variable	Number of cows	Mean	St. dev.
1BW	119	71.2	7.2
1WW	119	456.7	35.3
1WS	119	12.5	0.7
ABW	220	71.0	5.8
AWW	220	452.9	30.0
AWS	220	12.4	0.6
MPBW	220	69.1	2.9
MPWW	220	441.0	21.1
MPWS	220	12.3	0.3

[1] All weights are in pounds.

classification scores and the productivity measures are presented in Table 5.

The realtionship between first classification scores and the productivity measures were of particular interest because the typical breeder probably would only have his cow herd classified once. The cows in this study were classified from one to four times, the average number of classifications being 2.65. Therefore, it was of interest to evaluate the relationship between average classification scores and the productivity measures to determine if they were more highly associated with the productivity measures than were the first classification scores.

As can be seen in Table 5, the correlation coefficients of the first classification scores and the average classification scores with a particular productivity measure were very similar. Therefore, even though average classification score is expected to be a more accurate estimate of a cow's true type than first classification score, it did not have a markedly different relationship with the productivity measures. In view of this close agreement, the correlations of the first and average classification scores with the productivity measures will be discussed together.

Since total score consisted of a weighted average of the clasisfication subgroupings, the high (0.73 to 0.97) positive relationships generally obtained by correlating a component part with the total score were anticipated. Correlation coefficients between classification variables and measures of birth weight and weaning score ranged from —.08 to 0.07 and —.11 to 0.10, respectively. Most of these correlations were close to zero, suggesting there was virtually no relationship between classification scores and measures of birth weight or weaning score. There appears to be a slight negative relationship between measures of weaning weight and classification scores. These correlations ranged from —.18 to 0.04, and only one of the coefficients was greater than zero. Four of the 30 correlations involving a measure of weaning weight were significantly ($P<.05$) less than zero.

Cow weight had highly significant ($P<.01$) positive correlations with appearance, general appearance, beef character, and total score in both the first and average classification analyses. These data indicate a slight positive relationship between cow weight and measures of birth weight and weaning weight, with correlations ranging from 0.05 to 0.19 and 0.01 to 0.19 for the two measures, respectively. There appears to be a slight negative association between cow weight and measures of weaning score, with correlations ranging from —.19 to —.04.

In order to evaluate possible differences in the relationship of type classification score and cow productivity due to differences in season of classification or age group at first classification, correlation coefficients were determined within each age group for spring and fall classifications

Table 5. Correlations Between First and Average Classification and Weight Variables and Cow Productivity Measures.

	BRQL	GAPP	BFCR	TSC	WT	1BW	1WW	1WS	ABW	AWW	AWS	MPBW	MPWW	MPWS
First Classification														
APP	0.45[1]	0.94[1]	0.66[1]	0.87[1]	0.51[1]	—.05	—.02	—.08	0.04	—.04	—.05	0.06	0.00	0.00
BRQL		0.72[1]	0.62[1]	0.73[1]	0.12	0.02	0.00	0.04	0.02	—.10	0.09	—.05	—.16[2]	0.10
GAPP			0.75[1]	0.95[1]	0.44[1]	—.03	—.01	—.04	0.04	—.06	—.01	0.03	—.05	0.03
BFCR				0.93[1]	0.57[1]	—.08	0.00	0.01	—.04	—.14[2]	—.07	—.04	—.14[2]	—.05
TSC					0.53[1]	—.05	—.01	—.03	0.00	—.10	—.04	0.00	—.10	—.01
WT						0.12	0.19[2]	—.04	0.09	0.01	—.19[1]	0.18[1]	0.09	—.12
Average Classification														
APP	0.47[1]	0.94[1]	0.74[1]	0.89[1]	0.60[1]	—.01	—.03	—.11	0.03	—.07	—.02	0.04	—.06	0.00
BRQL		0.74[1]	0.68[1]	0.74[1]	0.13[2]	0.07	0.04	0.01	—.01	—.11	0.08	—.07	—.18[1]	0.07
GAPP			0.68[1]	0.97[1]	0.51[1]	0.03	—.01	—.08	0.02	—.09	0.01	0.01	—.11	0.02
BRCR				0.95[1]	0.51[1]	—.03	—.02	—.01	—.03	—.11	—.01	—.01	—.12	0.00
TSC					0.54[1]	0.01	—.01	—.06	—.01	—.10	0.00	—.01	—.11	0.01
WT						0.05	0.08	—.05	0.10	0.01	—.10	0.19[1]	0.10	—.04

[1] Significantly different from zero at the 0.01 probability level.
[2] Significantly different from zero at the 0.65 probability level.

separately and pooled over years. These analyses were conducted on data from 103 cows that were classified all four times (twice within each season). The cows were categorized according to age at first classification, there being 46, 41 and 16 2-, 3-, and 4-year-old cows, respectively.

The correlation coefficients between total score and the cow productivity variables are presented in Table 6. Correlations between both spring and fall scores and most probable birth weight were essentially zero for all age groups. The data indicated virtually no association between spring score and most probable weaning weight for the age group 2; however, there was a significant ($P<.05$) negative association for the fall classification score and MPWW. This pronounced change in spring and fall correlations for age group 2 was possibly the result of the younger cows having a greater change in condition due to lactation and, consequently, classification score from spring to fall.

A negative relationship was indicated between classification score and MPWW for age group 3, with the fall correlation coefficient being significantly ($P<.01$) less than zero. There were a limited number of cows in age group 4, therefore, the correlations for age group 4 should be interpreted with extreme caution. The negative correlations obtained for age groups 2 and 3 were probably the result of the better producing younger cows being in poorer condition due to heavy lactation, therefore, receiving lower classification scores. The younger cows in age groups 2 and 3 utilized their body stores of energy and nutrient intake for lactation, growth and maintenance; however, the older cows in age group 4 probably required very little energy for body growth. Therefore, the cows in age group 4 were likely in better condition and consequently would have received higher type classification scores.

The 0.16 correlation between spring score and most probable weaning score for age group 2 and the 0.14 and 0.18 correlations for age group

Table 6. Pooled Within Season Correlations Between Total Classification Scores and Productivity Measures for Cows of Different Ages.

Cow productivity measures	Cow age group at first classification (years)					
	2		3		4	
	Spring class.	Fall class.	Spring class.	Fall class.	Spring class.	Fall class.
MPBW	—.07	—.03	— .03	—.06	—.01	—.13
MPWW	—.02	—.24*	— .20	—.33**	—.15	—.03
MPWS	0.16	—.03	0.01	—.09	0.14	0.18

* Significantly different from zero at the 0.05 probability level.
** Significantly different from zero at the 0.01 probability level.

4 may indicate a slight positive relationship; however, the remaining correlations were close to zero. Both classification score and most probable weaning score were based on subjective evaluations; therefore, the correlation coefficients between these variables should be interpreted with caution.

Regression Analyses of Classification Scores and Productivity Measures on Average Cow Condition Score

The linear regression coefficients for average type classification and cow productivity measures on average cow condition score are presented in Table 7. The linear regression coefficient of a response variable (such as classification scores and cow productivity measures) on average condition score measures the amount of change in the response variable expected for each unit change in average condition score. For example, the regression coefficient of total score on condition score of 2.22 means that a one unit increase in condition score is expected to result in 2.22 units increase in total score.

The highly significant ($P<.01$) regression coefficients for beef character, breed qualities, general appearance, and total score on condition score indicate the fatter cows received higher type classification scores. The highly significant ($P<.01$) regression coefficient for cow weight on condition score indicates the heavier cows were fatter at classification. The regression coefficients for the birth weight measures on condition score were generally close to zero. The regression coefficients for the weaning weight measures on condition score ranged from —6.61 to —.18. The regression coefficients for the weaning score measures on condition score range from —.14 to —.004, with two of the negative co-

Table 7. Linear Regression Coefficients of Cow Type Classification and Productivity Measures on Condition Score.

Reponse variable	Regression coefficient	Reponse variable	Regression coefficient
APP	0.15	1WS	—0.004
BFCR	1.57**	ABW	0.37
BRQL	0.52**	AWW	—6.61[1]
GAPP	0.68**	AWS	—0.14
TSC	2.22**	MPBW	0.37
WT	58.61**	MPWW	—4.45[1]
1BW	0.25	MPWS	—0.08*
1WW	—0.18		

* Significantly different from zero at the 0.05 probability level.
** Significantly different from zero at the 0.01 probability level.
[1] Significantly different from zero at the 0.10 probability level.

efficients being significantly ($P<.05$) less than zero. These regression coefficients indicate that the better milking cows which weaned heavier, higher scoring calves were thinner and received lower classification scores at classification time.

Prediction Equations for Cow Productivity

One of the objectives of this study was to determine the accuracy of type classification score for predicting cow productivity. The producer is interested in information that has utility in estimating a heifer's future producing ability in order that the genetically superior heifers among those available are selected for replacements in the cow herd. In many cases, the only information available at the time replacement heifers are selected is weight and a subjective evaluation of conformation or type; therefore, prediction equations for MPWW were developed utilizing total classification score (TSC), condition score (COND) and 18-month adjusted weight (WT).

These prediction equations for MPWW were developed from data on 55 pregnant heifers that were classified at approximately 18 months of age (Table 8). The standard error of estimate is essentially the average deviation (or average miss) of the predicted MPWW value from the actual MPWW value. The coefficient of determination is a measure of the proportion of the variation in MPWW accounted for by the prediction equation. The smaller the standard error of estimate and the larger the coefficient of determination, the more accurate the prediction equation is in predicting MPWW.

The 55 heifers had an average MPWW of 439 pounds with a standand deviation of 20.4 pounds. Thus if the MPWW of every heifer was estimated to be this average amount, the heifer's actual MPWW would be missed by 20.4 pounds on the average. A relatively low linear relation-

Table 8. Prediction Equations for MPWW of Heifers Classified at 18 Months of age.

Prediction equation ($\hat{Y}$ = MPWW in pounds)	Coefficient of Determination	Standard Error of Estimate (lbs.)
$\hat{Y}$ = average MPWW = 439.3	----	20.4
$\hat{Y}$ = 485.1 — 0.593 (TSC)	0.008	20.5
$\hat{Y}$ = 367.8 + 0.094 (WT)	0.060	19.9
$\hat{Y}$ = 443.1 — 1.092 (COND)	0.002	20.6
$\hat{Y}$ = 427.4 — 0.952 (TSC) + 0.127 (WT) — 1.106 (COND)	0.091	20.0

ship existed between MPWW and total score, 18-month weight, and condition score; therefore, the prediction equations which included these variables alone or in combination were of little value. The standard error of estimate was not appreciably altered by using these prediction equations. These data suggest that knowledge of a cow's total score, adjusted weight, or condition score at 18 months of age and prior to calving is of little value in predicting MPWW. However, there was a 0.24 ($P<.01$) correlation coefficient between 18-month adjusted weight and MPWW, and although of limited value, it appeared to be the most accurate prediction of MPWW for heifers previous to calving.

Table 9 presents several prediction equations for MPWW and their coefficients of determination and standard errors of estimate determined from data on 51 cows classified in the fall after weaning their frist calf. The weaning weight of the cow's first calf (calf WW), and the cow's total score, weight, and condition score at classification were evaluated alone and together as predictors of MPWW. This group of 51 cows had an average MPWW of 439 pounds with a standard deviation of 18.3 pounds. Therefore, a prediction based on the average alone would miss the actual MPWW by 18.3 pounds on the average. A relatively low linear relationship existed between MPWW and total score, cow weight, and condition score; consequently, prediction equations involving these variables alone were of little value and did not appreciably alter the standard error of estimate. There was a highly significant ($P<.01$) linear relationship between MPWW and calf WW, and the prediction equation involving calf WW reduced the standard error of estimate (average miss) to 14.0 pounds. A prediction equation utilizing all four variables was no more accurate in predicting MPWW than the one utilizing calf WW alone. This is a further indication of the general lack of merit of total score, cow weight, and condition score for predicting MPWW in these data.

Table 9. Prediction Equations for MPWW of Cows Classified in the Fall After Weaning Their First Calf.

Prediction equation ($\hat{Y}$ = MPWW in pounds)	Coefficient of Determination	Standard Error of Estimate (lbs.)
$\hat{Y}$ = average MPWW = 438.6	----	18.3
$\hat{Y}$ = 564.9 — 1.614 (TSC)	0.032	18.2
$\hat{Y}$ = 416.8 + 0.030 (WT)	0.010	18.4
$\hat{Y}$ = 480.1 — 15.647 (COND)	0.068	17.8
$\hat{Y}$ = 296.2 + 0.317 (Calf WW)	0.422	14.0
$\hat{Y}$ = 363.1 — 1.396 (TSC) + 0.064 (WT) — 1.026 (COND) + 0.312 (Calf WW)	0.471	13.9

Summary

The results of this study suggest there is limited opportunity to apply selection pressure for increased cow productivity prior to a cow weaning her first calf; however, selecting replacement females on the basis of their 18-month adjusted weight would be of some value. Although some initial screening is necessary, under most commercial conditions similar to those in this study where the objective is to increase the productivity of the cow herd, delaying the final selection of herd replacement until after the first calf is weaned would seem justified. The general lack of correlation between classification scores and measures of productivity suggests that both classification score and performance data must be employed as selection criteria if improvement in type scores and level of performance are both goals of the breeding program.

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Milk Production of Range Cows

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Story in Brief

An experiment has been initiated to determine the influence of level of milk production of brood cows on productivity, supplemental feed requirements and efficiency of beef production. Three levels of milk production will be established with three kinds of females-Herefords, Hereford and Holstein crossbreds, and Holsteins. Three levels of supplement will be fed to determine the relationship between level of milk production and feed requirements. Growth curves of heifers during their first year on test and preliminary data on milk production and calf performance from a limited number of "pilot" females are presented.

In cooperation with the Agricultural Research Service, Animal Science Research Division, USDA.

Introduction

Today, considerable pressure is being exerted to increase milk production of range cows. Performance testing programs which emphasize weaning weight automatically result in selection for higher milk production. In addition, some cow-calf operators are infusing dairy breeding into their cow herd to rapidly increase milk production to a much higher level.

Research has shown a strong correlation between level of milk production of beef cows and weaning weight of their calves. Conversion of milk to calf also is rather efficient. Within the limits of milk produced by beef cows, each additional 10 pounds of milk produces approximately an additional pound of weaned calf. Conversion may not be as efficient at higher levels of milk production.

How much milk should a range cow produce? How much milk will a cow with a very high potential for milk production actually produce under range conditions? Will the capacity of a cow's calf limit her milk production? Will additional increments of milk production at high levels of milk yield be efficiently converted to calf weight? Will a heavy milking cow rebreed under range conditions? How much more supplement will a heavy milking cow need under range conditions? How will calves which are very heavy at weaning perform in the feedlot? What will be the carcass merit of calves which are very heavy at weaning time and consequently young at slaughter? What is the relationship between level of milk production and total efficiency of production of carcass beef, considering all feed consumed by the cow, by the calf before weaning and by the calf after weaning?

These are questions being asked, and they are all related to the main question, "How much milk should a range cow produce?" There well may be several answers to this question. Under an adverse feed environment (such as sparse range) a relatively low level of milk production may be necessary to allow good reproduction, while under a plentiful feed environment (such as improved pasture) a very high level of milk production may be desirable.

Experimental Procedure

To answer basic questions about level of milk production, an experiment has been initiated at the Oklahoma Experiment Station. Three levels of milk production will be established with three kinds of females: 1. Herefords 2. Hereford x Holstein crossbreeds 3. Holsteins.

The females will be subjected to three levels of supplement, moderate, high and very high. The moderate level will consist of that amount

of supplement which will allow Hereford females to be maintained in thrifty condition and reproduce at near maximum levels. The same amount of supplement will be fed to crossbreds and Holsteins. The high level of supplement will consist of that amount necessary to maintain crossbreds in a physiological condition comparable to moderate level Herefords. The high level of supplement will also be fed to Herefords and Holsteins. The very high level of supplement will consist of that amount necessary to maintain Holstein females in a physiological condition comparable to moderate level Herefords and high level crossbreds. The very high level of nutrition will not be used for Herefords and crossbreds.

One phase of the experiment will be conducted on the range to determine the actual performance of cows varying widely in milk production potential, and to determine their response to differing levels of supplementation. Production traits of major interest will be percent calf crop and weaning weight of calves.

A second phase will be conducted entirely in drylot so that all feed consumed by both cows and calves can be measured. This will allow determination of total efficiency of feed utilization by the weaned calf, as influenced by level of milk production and level of nutrition of the dam.

Calves will be placed in the feedlot at weaning time, fed to slaughter finish and critically evaluated in the carcass. This will allow determination of the total efficiency of beef production as influenced by milk production of the cow, considering all feed consumed by the cow, and by the calf before weaning and in the feedlot.

Results

Heifer calves for this experiment were obtained in the fall of 1969, wintered under range conditions on dry grass during the winter of 1969-70, and grazed on native grass during the summer of 1970. Growth curves of the heifers during the first year of the experiment are shown in Figure 1. Holsteins were heaviest and Herefords lightest initially, and breed differences in body weight increased somewhat during the year. This is as expected since ultimate mature size should rank in the order of Holsteins, Holsteins x Hereford crossbreeds, and Herefords.

Heifers were bred to one Angus bull through the use of artificial insemination; additional Angus bulls were used for cleanup pasture breeding. The heifers calved during November through February of 1970-71.

Eighteen two-year-old heifers (six Herefords, six Holstein x Hereford crossbreds, and six Holsteins) were obtained as bred yearling heifers in the fall of 1969 to serve as "pilot" females for obtaining preliminary information. The heifers calved during November through January of

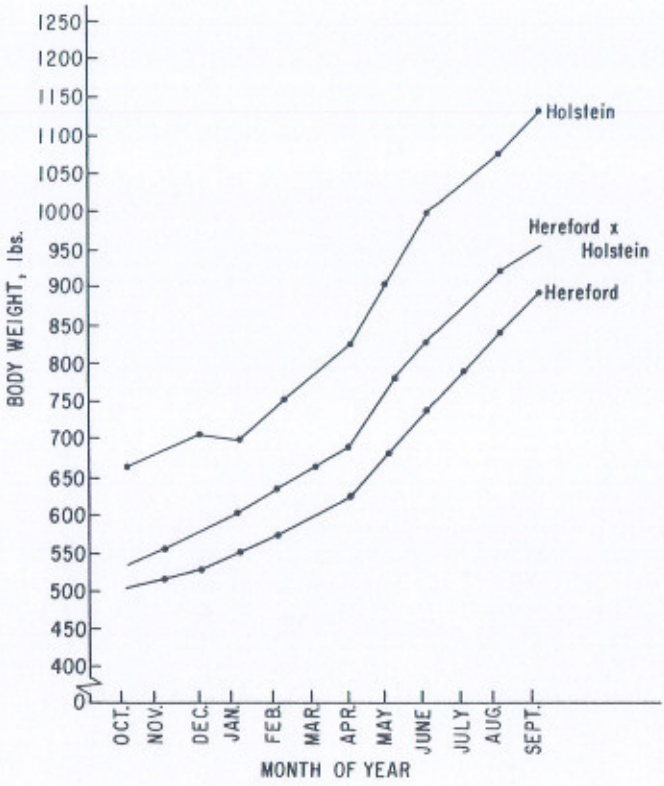

Figure 1. Body weight curves for yearling heifers.

1969-70. Changes in their body weight during the first year are shown in Table 1 and illustrated in Figure 2. It is interesting to note that the Herefords gained considerable weight, the Holstein x Hereford crossbreds gained much less weight, and the Holsteins gained very little weight, during the year which included calving and lactation. The relationship of such weight changes to rebreeding performance of females producing various levels of milk production is an important item to be determined in this experiment.

Average daily milk production to 205 and 270 days is shown in Table 1; the three types of females definitely produced three distinct levels of milk production. Monthly lactation curves are presented in Figure 3. The Hereford lactation curve illustrates the continuous decline in milk production normally observed in beef cows, while the lactation curve of the Holstein x Hereford crossbreds is more typical of a dairy

Table 1. Preliminary Data on Level of Milk Production.

	Breed		
	Hereford	Hereford x Holstein	Holstein
No. of heifers	5	6	6
Wt., October, 1969, lbs.	718	820	988
Wt., September, 1970, lbs.	882	855	1000
Ave. daily milk, 205 days, lbs.	12.2	21.6	28.4
Ave. daily milk, 270 days, lbs.	10.8	20.4	27.1
Ave. wt. of calves, 205 days, lbs.	390	456	504
Ave. wt. of calves, 270 days, lbs.	486	565	636

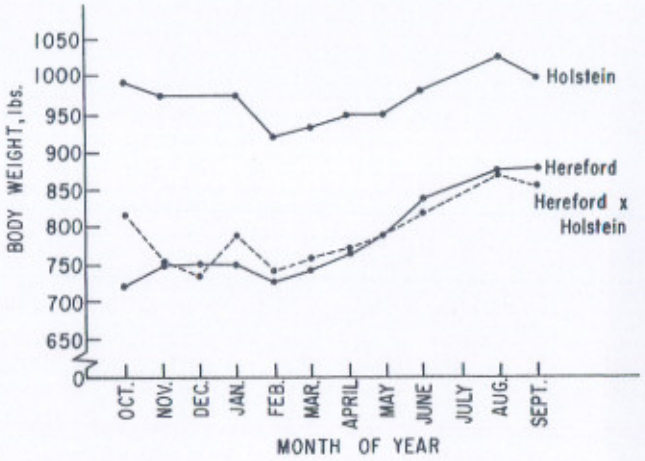

Figure 2. Body weight curves for two-year-old heifers.

lactation curve. The Holsteins produce more milk in late lactation than in early lactation. This was probably a reflection of an increasing capacity for milk by the calves as they increased in age, along with the potential of the cows to produce an increasing quantity of milk.

Differences in milk production were reflected in differences in weaning weight (Table 1). Calves from the Holstein x Hereford crossbreds were 66 and 79 pounds heavier than those from the Herefords at 205 and 270 days, respectively. The advantage for the calves produced by the Holsteins over those produced by the crossbreds at 205 and 270 days was 48 and 71 pounds, respectively. Determining whether such increases in weaning weight resulting from high levels of milk production are efficient and profitable is the major objective of this experiment.

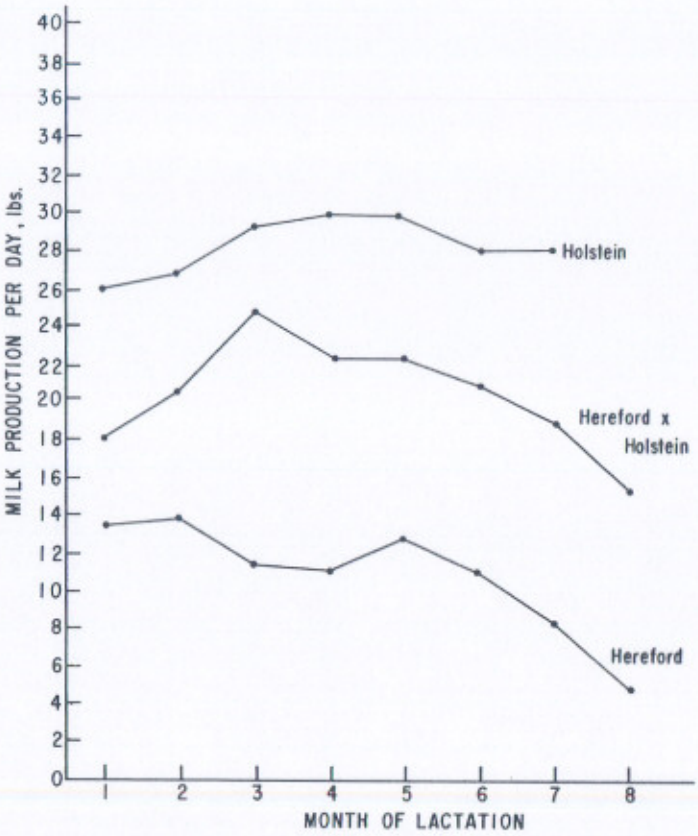

Figure 3. Milk production curves for two-year-old heifers.

Superovulation Of Beef Cows And Heifers By Injection Of Pregnant Mare Serum (PMS) Following Estrus Synchronization By Means Of An Oral Progestogen

D. B. Laster, E. J. Turman, D. F. Stephens and R. E. Renbarger

Story in Brief

The effect on ovulation rate of injections of PMS and HGC timed from a synchronized estrus was studied. Estrus was synchronized by feeding CAP for 18 days (10 mg./head/day for 16 days then 5.0 mg./head/day for 2 days). All PMS injections were timed from the average day of estrus, which was the third day after the last feeding of CAP.

A total of 46 yearling beef heifers and 19 lactating beef cows received subcutaneous injections of 1500 IU PMS and 18 cows received 1000 IU PMS on day-5 with all receiving a second injection of 2000 IU PMS on day-17 of the cycle. All PMS injections were subcutaneous. All animals received 4000 IU HCG, intravenously, the third day after the second PMS injection and were artificially inseminated at this time and 24 hours later.

The injection of 1500 IU PMS on day-5 gave more desirable results than did the 1000 IU level. Of the 64 cows and heifers receiving the 1500 IU dose, on day-5 followed by 2000 IU on day-17, 48.4 percent had the desired 2 or 3 egg ovulation and only 21.9 percent ovulated four or more eggs.

Twenty-four of 46 heifers (52.2 percent) and 18 of 37 cows (48.6 percent) conceived to the inseminations. However, only 5 heifers and 4 cows were still pregnant after 90 days. The reason for the high rate of embryonic mortality could not be determined. However, all cows and heifers were laparotomized 11 days following inseminations.

Introduction

A number of research studies have demonstrated that the incidence of multiple births in beef cattle can be increased by the injection of a

In cooperation with Fort Reno Livestock Research Station, Agricultural Research Service, Animal Science Division, USDA, El Reno, Oklahoma.

variety of gonadotropins, including pregnant mare serum (PMS). The results of an earlier study involving PMS injections conducted at the Fort Reno Livestock Research Station were reported at the 1969 Feeder's Day (Miscellaneous Publication No. 82).

Pregnant mare serum is processed from the blood serum of pregnant mares. It is rich in a gonadotropic substance which has a similar physiological activity to that of follicle stimulating hormone (FSH). FSH is one of the gonadotropic hormones produced by the anterior pituitary gland, and its effect is to stimulate the growth of the follicle on the ovary and the maturation of the ovum (egg) which it contains. The gonadotropic substance of PMS is produced by structures in the uterus that are associated with the placenta and, for this reason, it is referred to as a placental gonadotropin.

A second type of placental gonadotropin is produced by pregnant women. It is formed in the chorion, one of the membranes of the placenta, and is excreted in the urine. This gonadotropic substance is extracted from the urine of pregnant women by pharmaceutical houses, processed and sold under the name human chorionic gonadotropin (HCG). This material has a physiological activity similar to that of the luteinizing hormone (LH) produced by the anterior pituitary. It's effect in the body is to cause rupture (ovulation) of the mature follicle in the ovary and the release of the egg contained in the follicle.

If a cow is exposed to above normal levels of FSH, either because of overproduction by the pituitary or as a result of it being injected, more than one follicle will develop. If these follicles are subjected to ample levels of LH all should ovulate. This is known as superovulation. PMS and HCG provide a means, therefore, for researchers to stimulate superovulation by hormone injections.

Almost without exception, researchers in this field have reported high death losses among triplet and larger litters, but a relatively low mortality rate among twins. Therefore, the determination of the proper dose level and sequence of treatments that will result in a high percentage of two egg ovulations is one of the requirements for developing a practical program for the induction of the multiple births in cattle.

In addition, it is important that the gonadotropin injections be timed rather precisely during the estrous cycle with reference to the occurrence of estrus. This means there is a high labor requirement in checking for estrus and then injecting the cows on an individual basis according to the day that estrus occurred. Thus, it appears that a practical program must also include some type of estrus synchronization which will cause most of the cows to be in estrus within a period of two or three days. If estrus can be synchronized to this extent, it should be possible to give the gonadotropin injection to all cows on the same day.

The objective of the research being reported here was to study the effect of a sequence of PMS and HCG injections, timed from a synchronized estrus, that would result in a high percentage of two egg ovulations in beef cows and heifers.

Materials and Methods

This study included 37 non-lactating beef cows and 46 yearling beef heifers of Hereford, Angus, Hereford x Angus and Hereford x Angus x Holstein breeding maintained at the Fort Reno Livestock Research Station. The animals were randomly assigned to treatments on the basis of weight and breeding.

Estrus was synchronized by feeding 6-chloro-Δ^6-17 acetoxyprogesterone (CAP) [1], individually, for 18 days, 10 mg per day the first 16 days and 5 mg per day at the last 2 days. CAP feeding was started in all cows at the same time without regard to stage of the estrous cycle. The PMS injections were given during the estrous cycle following CAP feeding.

Gonadotropin treatment consisted of two subcutaneous injections of PMS[2] and a single intravenous injection of HCG[3]. The PMS injections were given to all animals on days 5 and 17 of the estrous cycle as timed from the average date of synchronized estrus. The average date of synchronized estrus was day-3 post-CAP, therefore, the PMS injections were given on days 8 and 20 after last feeding of CAP. HCG was injected on the third day following the second PMS injection.

The occurrence of estrus was determined by the use of sterilized bulls running with the cows at all times. Ovulation rate was determined by counting the corpora lutea on the ovaries exposed by means of a laparotomy carried out 5 to 13 days after HCG administration. All breeding was by means of artificial insemination using frozen semen obtained from a commercial bull stud.

Trial 1

Fifteen Hereford and 31 Angus heifers, weighing 580 to 800 lb. were employed. The heifers were on native pasture with milo fed at the rate of 2.0 lb. per day for the first phase of the trial, and milo increased to 10.0 lb. per day during the second phase.

In phase 1 a total of 30 heifers were synchronized by feeding CAP and treated with 1,500 IU PMS on day 5 and 2,000 IU PMS on day 17 of the post-CAP estrous cycle. All PMS treated heifers were injected with 4,000 IU HCG on day 3 post-PMS and were inseminated twice: at the

[1] Eli Lilly Company, Greenfield Laboratories, Greenfield, Indiana.
[2] Lyophilized powder containing 100 IU PMS/mg supplied by the Eli Lilly Company, Greenfield Laboratories, Greenfield, Indiana.
[3] Lyophilized powder containing 80 IU HCG/mg supplied by the Eli Lilly Company, Greenfield Laboratories, Greenfield, Indiana.

time of the HCG injections and 24 hours later. Sixteen heifers were also fed CAP, but were not treated with PMS and served as controls. The control heifers were not inseminated.

A high lumbar laparotomy was performed on all control heifers and on one-half of the PMS treated heifers 5 days following the first PMS injection to observe the effect of this injection on the ovaries. A second high lumbar laparotomy was performed on all heifers 11 days after the HCG injections and inseminations. Response to PMS was determined from numbers and location of corpora lutea and the location and size of follicles were recorded.

The second phase of the trial included all heifers of the control group and the 19 PMS treated heifers that had failed to conceive to inseminations following the PMS and HCG injections of phase 1. Each heifer received 1,500 and 2,000 IU PMS on days 5 and 17, respectively, timed from the estrus following the second laparotomy of the first phase. All heifers received 4,000 IU HCG on day 3 following the second PMS injection and were inseminated at the time of HCG administration and 24 hours later. A high lumbar laparotomy was performed 5 to 12 days following the HCG injections to determine response to PMS.

Heifers not returning to estrus were considered to have settled and this was confirmed by rectal palpation carried out 30, 60 and 90 days after insemination. All heifers, diagnosed pregnant at 30 days post-insemination, were slaughtered 90 days following insemination and the reproductive tracts were recovered.

Trial 2

Twenty-one Hereford, three Angus and 13 Hereford x Angus cows, weighing from 870 to 1300 lb. were used. The cows were maintained on native pasture and were fed 5.0 lb. milo plus 2.0 lb. 43 percent cottonseed cake per day. During the CAP feeding period the daily feed was 2.0 lb. milo containing the daily dose of CAP.

All cows were fed CAP and the initial sequence of PMS injections were timed from the average date of post-CAP estrus. Eighteen cows received 1,500 IU PMS on day 5. All cows received 2,000 IU PMS on day 17 of the estrous cycle and 4,000 IU HCG on day 3 post-PMS. All cows were inseminated on the day of HCG injection and 24 hours later.

Cows that came back in estrus within 45 days post-insemination were retreated with PMS and inseminated in the same manner as described for the heifers that received a second sequence of injections in trial 1. Conception was determined as described for trial 1, except no palpations were made 30 days following inseminations after the second sequence of injections. A high lumbar laparotomy to determine effect of PMS on the ovaries was performed on all cows 5 to 12 days following the HCG injections.

Results

Trial 1

This trial, conducted from August, 1969 to February, 1970, was designed to study ovulation rates of heifers administered PMS following a synchronized estrus with HCG given on day 3 post-PMS.

Ovulation rates of the heifers following the initial (phase 1) and second sequence (phase 2) of PMS injections are presented in Table 1. The mean ovulation rate was 2.33 eggs with 40 percent of the heifers ovulating two eggs and 10 percent ovulating 3 eggs. Only 16.6 percent of the heifers ovulated more than 3 eggs but 33.4 percent failed to respond to PMS and had only a single ovulation (9 heifers) or no ovulation (1 heifer).

The heifers appeared to develop a refractoriness to PMS since only 51.6 percent of the heifers retreated with PMS gave a superovulatory response compared to 80.0 percent of the control group that were being treated for the first time (Table 1). The mean ovulation rates were 1.95 and 3.0 in the retreated and control groups, respectively.

Twenty-four of the 46 heifers (52.2 percent) in trial 1 conceived to insemination following PMS and HCG injections; 10/30 (33.3 percent) following the initial sequence of injections timed from post-PMS estrus, 7/19 (36.8 percent) of the heifers receiving the second sequence of PMS injections and 7/15 (46.7 percent) of the heifers which were used as controls during the initial phase of the trial.

Of the 24 heifers diagnosed to be pregnant 30 days after insemination, only 9 were pregnant at 60 days and only 5 were pregnant at 90 days post-insemination. Examination of the reproductive tracts from the 19 heifers, diagnosed pregnant 30 days post-insemination but which were

Table 1. Ovulation Rates of Beef Heifers Treated with 1500 IU PMS on Day 5 and 2000 IU PMS on Day 17 of the Estrous Cycle and 4000 IU HCG on Day 3 Post-PMS (Trial 1)

Treatment	No. heifers	No. of heifers with This no. of corpora lutea/heifer								
		0	1	2	3	4	5	6	7	8
Received initial PMS sequence	30	1	9	12	3	1	0	4	0	0
Retreated with PMS—Received second PMS sequence	19	1	8	8	0	0	1	0	0	1
Controls-Received only second PMS sequence	15	1	2	4	1	5	1	0	1	0

not pregnant when slaughtered 90 days post-insemination confirmed that the heifers had been pregnant and had apparently resorbed the fetusses.

There was a higher conception rate in heifers with single ovulations, (47.3 percent) than in those with multiple ovulations (37.5 percent). However, there appeared to be no relationship between number of ovulations and maintenance of pregnancy since the five heifers pregnant at 90 days had each ovulated more than one ova. All fetuses appeared to be viable and there was no evidence of fetal resorption in the pregnant heifers. Three of the 5 pregnant heifers had multiple fetuses with the numbers of corpora lutea (CL) and numbers of fetuses as follows: 2 CL, 1 fetus; 3 CL, 1 fetus; 5 CL, 2 fetuses; 4 CL, 3 fetuses; 4 CL, 3 fetuses.

Trial 2

This trial, conducted from October, 1969 to April, 1970, was designed to study the effects of two levels of PMS given at the first injection on the ovulation rates of cows.

The ovulation rates of the cows following the initial and second sequence of PMS injections are presented in table 2. Following the initial PMS and HCG treatment, mean ovulation rate was 2.22 and 2.37 for cows given 1,000 and 1,500 IU PMS, respectively, on day 5 of the estrous cycle. However, cows given 1,500 compared to 1,000 IU PMS on day 5 tended to have more two and three egg ovulations, 57.9 percent *vs.* 33.3 percent and fewer 4-plus egg ovulations, 10.5 percent *vs.* 22.2 percent.

Although a control group of cows was not available for comparison, the cows also appeared to be somewhat refractory to the second sequence of PMS and HCG injections (table 3). Only 37.0 percent of the cows gave a superovulatory response and the mean ovulation rate was 1.56 following the second sequence of injections, compared to 68.4 percent and

Table 2. Ovulation Rates of Beef Cows Treated with 1000 or 1500 IU PMS on Day 5 and 2000 IU PMS on Day 17 of the Estrous Cycle and 4000 IU HCG on Day 3 Post-PMS (Trial 2).

Treatment	Total treated	No. of heifers with This no. of corpora lutea/cow									
		0	1	2	3	4	5	6	7	8	9
Initial PMS treatment[1]	18	1	7	4	2	3	0	0	1	0	0
Initial PMS treatment[2]	19	0	6	7	4	1	0	0	0	0	1
Retreated with PMS[3]	27	2	15	6	2	1	1	0	0	0	0

[1] Received 1,000 IU PMS on day 5, 2,000 IU on day 17.
[2] Received 1,500 IU PMS on day 5, 2,000 IU on day 17.
[3] Received 1,500 IU PMS on day 5, 2,000 IU on day 17.

2.37 following the initial treatment of PMS timed from post-CAP estrus.

Conception rate, based on non-return to estrus by 45 days post-insemination, was 48.6 percent. Nine of the 37 cows conceived following the first sequence of gonadotrophin injections and nine additional cows conceived following the second sequence of injections.

Rectal palpation 60 days post insemination of the nine cows that did not return to estrus following the initial sequence of gonadotrophin injections revealed that all cows had apparently been pregnant earlier but by 60 days the embryos had died and were being resorbed. A similar situation was found at 60 days post-insemination in five of the nine cows, which had not come back in heat within 60 days following the second sequence of injections. The four cows pregnant at 60 days post-insemination were also pregnant at 90 days post-insemination. All subsequently calved with one cow producing twins.

Results and Discussion

The results obtained in this study suggests that PMS injections may be timed from a synchronized estrus. Of the 64 cows and heifers receiving 1,500 IU PMS on day 5 and 2,000 IU PMS on day 17, 48.4 percent had the desired 2 or 3 egg ovulation. Although 29.7 percent did not respond with more than one ovulation, it is encouraging that only 21.9 percent ovulated four or more eggs. From the standpoint of limiting births to no more than twins it is essential that the number of 4+ ovulations be reduced as much as possible.

The reduced superovulatory response to a second sequence of PMS injections was not unexpected. It has been reported by other researchers that cows develop a refractoriness to repeated PMS injections.

The reason for the low conception rate and high rate of embryonic mortality could not be determined in this study. It has been reported that rectal palpations early in pregnancy will cause abortion of as much as one-third of the pregnancies. Other researchers have also reported low conception and pregnancy rates in PMS treated heifers which were laparotomized following breeding. Both laparotomies and rectal palpations were carried out in this study. It will remain for future research to determine whether this low fertility is typical of PMS treatments following estrus synchronization, or whether it was the result of excessive handling of the tract as a result of the palpations and laparotomies.

Although there is no doubt that superovulation can be induced by hormone injections, this means of increasing multiple births in beef cattle is still strictly experimental. The research conducted to date has revealed a number of important problems which must be resolved by additional research if such treatments are to ever be made practical.

Creep-Feeding Spring-Born Beef Calves Grazing Bermudagrass Pasture

J. E. McCroskey, R. Renbarger and J. Eason

Story In Brief

A creep-feeding study involving 68 spring-born nursing beef calves grazing bermudagrass pasture was conducted to compare the effectiveness of three widely different types of creep-feeds for increasing weaning weights and net returns. One group received no creep and served as controls. The three creep-feeds compared were (1) sudangrass pasture; (2) alfalfa hay pellets; and (3) a high-protein, high-energy mixed ration.

Weaning weights of all creep-fed lots were higher than weights of control calves. Increases in weaning weights above controls were 8.0, 10.1, and 14.0 percent, respectively, for lots receiving sudangrass pasture, pelleted alfalfa hay, and the mixed ration. Sudangrass showed considerable promise as a creep-pasture in the early part of the study but growth stopped due to lack of moisture. Feed required for each additional pound of gain above the controls were 9.6 and 9.4 lb. for lots fed alfalfa hay pellets and the mixed ration, respectively.

Introduction

Field reports and research data indicate that spring-born beef calves reared on bermudagrass pasture frequently wean at lighter weights than calves grown on native-grass pastures. It has been theorized that part of the reason for lighter weaning weights is reduced forage intake during the latter part of the summer when forage quality declines. A decrease in forage consumption would result in reduced total energy intake since the calf depends upon pasture as a source of nutrients and energy to a greater degree with increasing age and size.

The three non-genetic means of increasing calf gains and weaning weights would be to increase milk consumption, forage consumption, or provide supplemental feed in order to increase energy and nutrient intake. Although it is possible to improve forage quality through management practices, it would be difficult to bring about sufficient change in forage quality to promote increases in forage digestible energy intake suf-

In cooperation with the Agricultural Research Service, Animal Science Research Division, USDA.

ficient to foster significant improvement in calf-gain. Likewise, increased milk production by the dam sufficient to cause appreciable changes in calf gains would require supplemental feeding of the cow herd, which is not economically feasible. Hence, creep-feeding in some manner appears to be the most logical and simplest means of increasing the energy and nutrient intake by the nursing-grazing calf.

Creep-feeding studies have consistantly shown an increase in weaning weight but frequently have failed to show an economic advantage due to the cost and rather inefficient use of creep-feeds. Oklahoma studies with nursing calves grazing native grass pastures have shown that alfalfa hay or pelleted alfalfa hay is comparable to mixed grain rations as creep-feeds in increasing calf gains. Furthermore, alfalfa has been a more profitable creep-feed than single grains or grain mixtures.

The purpose of this study was to determine the growth promoting effectiveness and economic feasibility of a wide variety of types of creep-feeds for spring-born nursing beef calves grazing a pure stand of Midland Bermudagrass.

Materials and Methods

Sixty-eight spring-born calves from Hereford, Angus x Hereford, and Angus x Holstein cows were divided into four groups as equally as possible on the basis of breed of dam, sex of calf, and age of calf. The four groups of calves were assigned to the following treatments: Lot 1-control (no creep-feed); Lot 2-sudangrass creep-pasture; Lot 3-pelleted alfalfa hay; and Lot 4-high-protein, high-energy mixed ration. Since bermudagrass quality remains rather good until July and since calves do not begin to consume pasture or dry feed to an appreciable extent until they are three to four months of age, creep-feeding was not begun until mid-summer. Initial shrunk weights of calves were taken on July 21, 1970 following approximately a two-week period of adjustment to the respective treatments. Calves were weighed at approximately 28-day intervals and remained on the four treatments until weaning (83 days).

In Lot 2, approximately two acres of Piper Sudangrass was seeded adjacent to three of the bermudagrass pastures approximately 30 days prior to the start of the adjustment period. The lower wire of the fence separating the sudangrass and bermudagrass pastures was raised to allow calves to graze the sudangrass at will while cows were kept out. One-half of the creep-pasture was alternately mowed at alternately intervals to allow for continuous availability of new growth. Due to lack of rain during the latter part of the summer, the sudangrass lasted for only about 45 days after initial weights were taken. In lot 3, good quality alfalfa hay was ground and made into 3/8 inch pellets and fed free-choice in a self-feeder.

Seven percent molasses was added to reduce dustiness and enhance the pelleting process. A high-protein, high-energy mixed ration was fed to lot 4 free-choice in a self-feeder. The composition of the ration is shown in Table 1.

Cows and calves in the four treatment groups were rotated at weekly intervals among seven bermudagrass pastures in order to minimize pasture effect. Cows and calves assigned to lot 2 were restricted in rotation to the three pastures adjacent to the sudangrass creep-pasture. These pastures plus four others were used in the rotational scheme for lots 1, 3 and 4. Bermudagrass pastures were fertilized with 50 lb. each of P_2O_5 and K_2O per acre in May, plus 150 lb. of nitrogen per acre, in the form of ammonium nitrate, applied in three equal applications in May, July and August. A mineral mixture composed of two parts trace mineralized salt and one part dicalcium phosphate was available free-choice to cows and calves in all lots.

Table 1. Composition of Creep Ration Fed to Lot 4

Ingredient	% of Ration
Rolled milo	22
Rolled oats	22
Rolled corn	22
Soybean meal	20
Dehydrated alfalfa meal	6
Molasses	7
T. M. salt	0
Dikal	0
Vit. A (6,500 I.U./lb)	
Aureomycin (1 lb. Aurofac-40/ton)	

Results and Discussion

Calf weights, gains and feed consumption data are shown in Table 2. The control group (lot 1) had the lowest average daily gains at all intervals and the lowest weaning weights. Average weaning weights in lots 2, 3, and 4 were 35, 44, and 61 pounds heavier, respectively, than the average of lot 1. Calves in lot 4 were decidedly fatter at weaning than those in the other lots. It should be pointed out that average daily gains in lot 2 (sudangrass creep-pasture) ranked second to those in lot 4 (mixed ration) through the first 54 days of the study. As pointed out previously, sudangrass forage was good for about 45 days but growth stopped due to lack of rain. Thus, weaning weights in that lot would likely have been higher if the creep-pasture had lasted for the entire study.

Table 2. Calf Weights and Creep-Feed Consumption

Lot No.	1	2	3	4
Treatment	Control	Sudangrass[1]	Pel. Alf.	Mixed[2] Ration
No. calves/lot	16	17	17	18
Initial wt. (lb.)	310	314	317	309
Ave. weaning wt. (lb.)	437	472	481	498
Advantage over Lot 1 (lb.)	--	35	44	61
Wn. wt. as % of control	100.0	108.0	110.1	114.0
Ave. daily Gain (lb.):				
28 days	1.86	2.43	2.11	2.64
54 days	1.81	2.30	2.24	2.63
83 days	1.53	1.90	1.98	2.28
Creep-feed (lb.):				
Total/calf	--	No measure	423	573
Feed/calf/day	--	No measure	5.1	6.9
Feed/added lb. gain	--	No measure	9.6	9.4

[1] Sudangrass creep-pasture lasted only about 45 days.
[2] Mixed ration formula shown in Table 1.

Calves in lot 3 consumed less total creep-feed than those in lot 4, especially during the first 28-day period, indicating that alfalfa pellets were less palatable than the mixed ration. The calves slowly adapted to the alfalfa pellets, resulting in increased gains between the 28 and 54-day weights. Feed efficiency expressed as feed required for each additional pound of gain above that of the control lot was 9.6 and 9.4 for lots 3 and 4, respectively. Hence, alfalfa pellets were used about as efficiently as the mixed ration. Consumption of creep-pasture in lot 2 was not measured, therefore efficiency of pasture conversion can not be calculated.

During the early part of the study when the sudangrass was growing rapidly, calves grazed the creep-pasture rather heavily. Forage quality was controlled to a degree by mowing half of the pasture when it got too rank, thus providing both new and older growth. The two-acre area provided a sufficient amount of creep-pasture for the 17 calves as long as soil moisture was adequate. Had the sudangrass plot been irrigated there would have been abundant creep-pasture to weaning time.

Economic aspects of the study are shown in Table 3. Cost of sudangrass pasture was estimated to be $12.50 per acre and the alfalfa pellets estimated to cost $50.00/ton, including processing. The ration fed to lot 4 was mixed by a commercial mill and the actual cost was $80.00/ton. The price of this mixture could probably be reduced considerably if mixed on the farm or if purchased in larger quantities, thus making it more economically practical.

Total creep costs per calf were $1.47, $10.50, and $23.03 for lots 2, 3, and 4, respectively. The net advantage per calf due to creep-feeding was $10.78, $4.90, and -$1.68 for lots 2, 3, and 4, respectively, using the prices

Table 3. Economic Comparisons

Lot No.	1	2	3	4
Treatment	Control	Sudangrass[1]	Pel. Alf.	Mixed[2] Ration
Cost of creep ($)	--	12.50/A.	50.00/T.	80.00/T.
Creep cost/calf ($)	--	1.47	10.50	23.03
Cost/added lb. (¢)	--	4.2	28.1	37.0
Ave. calf value[3] ($)	152.95	165.20	168.35	174.30
Calf minus creep ($)	152.95	163.73	157.85	151.27
Net due to creep ($)	--	10.78	4.90	—1.68
Breakeven creep cost[3] ($)	--	104.12/A.	62.20/T.	75.60/T.

[1] Sudangrass creep-pasture lasted only about 45 days.
[2] Mixed ration formula shown in Table 1.
[3] Based on 35¢/lb. for weaned calves.

described and assuming a sale price of 35¢ per pound for all calves. This assumes no price reduction for heavier, fatter calves in lot 4. If there were a reduction in price per pound the mixed ration would have been even less profitable.

Since cost of feed is so highly variable, the breakeven cost was computed based on a sale price of 35¢/lb. of calves on all treatments. Note that the creep-pasture would be the one from which a profit could most easily be realized.

Results of this study indicate that gains and weaning weights of nursing calves grazing bermudagrass pasture during the growing season can be increased by widely different types of creep-feeds. The greatest increase in weights was obtained with the high-protein, high-energy mixed ration but the cost of the mixture makes its economic feasibility questionable. Pelleted high quality alfalfa hay shows promise both from the standpoint of increasing calf gains and net returns. From an economic standpoint creep-pastures such as sudangrass or other high quality warm season annuals appear to show considerable promise.

Success of this type of creep depends largely upon the adequacy of rainfall and/or the availability of irrigation water. The advantage in calf gains of lot 2 over lot 1 strongly suggests that during the latter part of the nursing period calf gains are influenced to a great degree by the quality of forage available, and that bermudagrass quality during this period of time is too low to permit maximum gain.

Self-Fed Liquid and Dry Supplements for Wintering Range Cows

Robert Totusek, J. W. Holloway and W. E. Sharp

Story In Brief

Liquid self-fed supplements, and dry self-fed supplements containing urea or feed grade biuret to furnish one-half of the protein equivalent, were compared to supplements containing only natural protein for range cows.

In one trial during which some prairie hay was fed, weight loss of cows on liquid supplement was similar to that of cows on natural protein. In another trial when only dry grass was available, weight loss was greater on liquid supplement. In both trials, condition of cows and weaning weight of calves tended to favor the natural protein supplements.

The dry self-fed supplements containing urea or feed grade biuret produced results almost as good as a natural protein supplement, and suggest excellent potential for increasing the utilization of non-protein-nitrogen sources for range cattle.

Introduction

There is much interest today in the self-feeding of supplements to range cows. One of the primary reasons for this current interest is the decreasing availability, and increasing cost, of labor.

Much research at the Oklahoma Experiment Station the past 20 years conclusively showed that the intake of cottonseed meal and other protein supplements could be restricted to a desired level by combining with salt, with no deterimental effects on cattle.

There is also renewed interest in self-feeding as a possibility to improve the utilization of non-protein-nitrogen sources (protein replacers) such as urea. Urea is rapidly converted to ammonia in the rumen of cattle, and much of the ammonia is lost before it can be converted to protein. It is possible that the frequent consumption of a urea supplement will result in less loss than when the supplement is consumed daily or every other day.

Liquid supplements are being fed in increasing quantity, primarily because of convenience in feeding. They can be delivered to the self-feeding tank in the pasture with no handling required on the part of the cat-

tleman, and as with any self-fed supplement little labor is required for feeding.

The use of liquid supplements is facilitated by the fact that certain feed ingredients such as urea, phosphorus sources, trace minerals and vitamins are soluble and can be satisfactorily combined with liquid feeds such as molasses. Some ingredients such as urea and phosphoric acid (a source of phosphorus) help to limit the intake.

Most liquid supplements contain urea as the principal source of nitrogen, rather than sources of natural protein such as cottonseed meal or soybean meal. Urea is efficiently utilized as a partial protein replacer in feedlot rations, but its utilization has been less satisfactory under range conditions.

Biuret is another non-protein-nitrogen compound which has potential as a protein replacer for range cattle. It is of interest particularly because it is broken down less rapidly and is less toxic than urea.

The object of the experiments reported here was to compare liquid self-fed supplements and dry self-fed supplements containing urea and biuret to dry supplements containing only natural protein.

Procedure

The trials were conducted at the Lake Carl Blackwell Experimental Range near Stillwater. Experimental cows were Angus and Herefords. Treatment groups were equalized with respect to age and/or breed when more than one breed and/or age was involved in a trial. Calves were born during February, March and April and weaned in early October. Cows grazed native tall grass pastures and were rotated among pastures in each trial. A mineral mix of equal parts salt and dicalcium phosphate was fed free choice.

Trial 1

Trial 1 was conducted during the winter of 1968-69, from December 6 to April 25, a period of 140 days. Angus and Hereford cows five years of age were divided into two groups within each breed. One of each of the breed groups received a dry pelleted supplement containing 25 percent crude protein; all of the protein was natural protein. Major ingredients were cottonseed meal and milo, with 5 percent alfalfa and 5 percent liquid molasses. The supplement was fortified to contain 1.25 percent phosphorus and vitamin A at a level of 10,000 I.U. per pound. This supplement was fed three times each week at an equivalent rate of 3 pounds per cow daily.

The second of each of the breed groups was self-fed a liquid supplement with a protein equivalent of 30 percent, 28.1 percent of which was

contributed by urea (45 percent nitrogen) at a level of 10 percent of the supplement. The liquid supplement was fortified with trace minerals, phosphoric acid to furnish 1.25 percent phosphorus, and vitamin A at a level of 10,000 I.U. per pound.

Prairie hay was fed at a rate of 10 lb. per cow daily beginning when calving started February 1.

Trial 2

Trials 2 and 3 were conducted during the winter of 1969-70, from November 21 to April 9, a period of 139 days. Angus and Hereford cows, four and five years of age in Trial 2 and six years of age in Trial 3, were divided into three and four similar groups for Trials 2 and 3, respectively. Three dry supplements were self-fed in both trials, and a liquid supplement was also self-fed in Trial 3; all supplements contained 30 percent protein equivalent. One dry supplement contained only natural protein, a second contained urea to furnish one-half of the protein equivalent, and a third contained a feedgrade biuret[1] to furnish one-half of the protein equivalent. All three supplements were formulated to contain 1.5 percent phosphorus, 0.5 percent calcium, 0.5 percent sulfur, 5 percent alfalfa meal and 5 percent liquid molasses. Major ingredients were wheat and soybean meal. Consumption of the dry supplements was regulated at desired levels by the inclusion of salt.

The liquid supplement[2] was similar to the one fed in Trial 1. Consumption was limited when necessary with aluminum sulfate at levels of 10 to 20 lb. per ton of supplement.

Prairie hay was fed in Trials 2 and 3 only when snow covered the grass.

Results

Trial 1

Consumption of the self-fed liquid supplement averaged 4.2 lb. per cow daily, compared to 3.0 lb. of the natural protein supplement which was hand-fed. Results are summarized in Table 1.

Total winter weight losses were similar and not significantly affected by type of supplement. However, the patterns of weight loss were considerably different. During the first 28 days of the trial, cows fed the natural protein supplement gained 9 lb. per cow while those fed the liquid supplement lost 48 pounds. This period included two weeks of severely cold weather during which the intake of liquid supplement was very low. Subsequently, the cows on the natural protein supplement lost

[1]Kedlor, furnished by Farmland Industries Kansas City, Missouri.
[2]Supplied courtesy of National Molasses Company, Willow Grove, Pennsylvania, and Lyle Perry, Waskomis.

Table 1. Trial 1: A Comparison of a Liquid-Urea Supplement With a Natural Protein Supplement

Breed	Angus		Hereford		Breeds combined	
Type of supplement	Control[1]	Liquid[2]	Control	Liquid	Control	Liquid
No. cows	14	13	10	10	24	23
Initial wt., 12-6-68, lb.	914	906	987	990	945	943
Final wt., 4-25-69, lb.	770	778	854	862	805	815
Wt. change lb.	—144	—128	—133	—128	—139	—128
Birth wt. of calves, lb.	54	53	63	62	58	57
Weaning wt. of calves, lb.	462	445	442	422	455	436

[1] A dry supplement containing 25% protein equivalent, all natural protein.
[2] A molasses-base supplement containing 30% protein equivalent, including 28.1% from urea.

more weight than cows on liquid supplement. The improved performance of the liquid supplement during late winter may have been associated with the feeding of prairie hay beginning February 1, since previous research has shown that urea is utilized more satisfactorily with hay than with dry grass. The cows fed liquid supplement appeared to be in poorer condition at the end of winter, but this difference was not reflected in body weight.

Birth weight of calves was not affected by type of supplement. Although weaning weights favored the natural protein groups, by 17, 20, and 19 lb. for the comparisons involving Angus, Herefords, and combined breeds, respectively, the differences were not satistically significant.

The type of supplement fed was without apparent affect on the rebreeding performance of the cows.

Trial 2

Results are shown in Table 2. The average daily intake of supplements was regulated rather effectively with salt; there was only 0.09 lb. difference between the low and high consuming groups. Although differences in average winter weight change were not large, weight changes within groups were consistent and consequently the differences were statistically significant. Cows on natural protein gained 32 lb. more than cows on the urea supplement, which in turn had an advantage in weight change of 16 lb. over the cows on the biuret supplement. Condition scores at the end of the wintering period followed the same trend as weight changes, but differences were not statistically significant.

Cows were pasture exposed to bulls for a 45-day period. Most of the cows conceived. With the short breeding season and limited numbers of cows involved it is not possible to make meaningful conclusions regarding treatment effects on conception.

Table 2. Trials 2 and 3. A Comparison of Self-fed Liquid and Dry Supplements for Range Cows

	Supplement[1] (all self-fed)			
	Natural protein (dry)	Urea[2] (dry)	Kedlor[3] (dry)	Liquid supplement[3]
Trial 2: Open cows				
No. cows	10	11	10	
Daily supplement, lb.	2.93	2.87	2.96	
Daily salt, lb.	1.03	.79	.81	
Av. % salt	26.0	21.6	21.5	
Initial wt., 11-21-69, lb.	852	885	862	
Final wt., 4-9-70, lb.	889	890	851	
Wt. change, lb.[4]	+37	+5	−11	
Condition score, 4-9-70[5]	4.4	4.0	3.6	
No. cows bred	8	11	9	
Trial 3: Bred-lactating cows				
No. cows	9	10	9	10
Daily supplement, lb.	3.26	3.25	3.19	3.20
Daily salt, lb.	1.28	.90	1.17	
Av. % salt	28.3	21.7	26.8	
Initial wt., 11-21-69, lbs.	1038	1031	1050	1015
Final wt., 4-9-70, lb.	927	980	955	860
Wt. change, lb.[4]	—111	—51	—95	—155
Condition score,[4] 4-9-70[5 6]	4.2	4.0	3.9	3.2
Birth wt. of calves, lb.	65	69	77	70
Weaning wt. of calves, lb.	413	401	397	380
No. cows rebred	8	10	6	7

[1] All supplements contained 30% protein equivalent.
[2] To supply 50% of protein equivalent.
[3] Approximately 90% of protein equivalent from urea.
[4] Weight damage of cows was significantly affected by treatment ($P<.01$).
[5] On a 1-9 basis, with 1 the poorest condition and 9 the highest.
[6] Significantly affected by treatment ($P<.05$).

Trial 3

As in Trial 2, the average daily intake of all supplements, including liquid supplement, was very similar, with a range of only 0.07 pound. The intake of liquid supplement was very high, approximately 9 lb. per cow daily, at the beginning of the trial. Aluminum sulfate was effective in limiting intake. During the latter part of the trial, in late March and April, intake of the liquid supplement was very low, even without aluminum sulfate. In both Trials 2 and 3, considerable variation in intake of dry supplements was noted as cows were rotated among pastures.

Type of supplement had a significant influence on total winter weight loss. Cows on liquid supplement lost the most weight, followed by those on natural protein, biuret, and urea. However, condition score was also significantly affected, and the cows ranked in the order of natural protein, urea, biuret and liquid supplement, from best to poorest.

Differences in birth weight and weaning weight were not statistically significant. However, it is interesting to note that weaning weights follow-

ed the same trend as condition scores. The biggest difference in weaning weight, 33 lb., was observed between cows fed the natural protein supplement and liquid supplement.

Conclusions

Results with self-fed supplements were encouraging. Although liquid supplement was not totally comparable to natural protein supplements, it is significant that performance on a product containing such a high proportion of its total protein equivalent from urea was as good as it was. The liquid protein seemed to be less satisfactory than natural protein supplements in two trials in terms of condition of the cows and weaning weight of the calves; as well as in body weight loss of cows in one trial when dry grass served as the only roughage.

The dry self-fed supplements containing either urea or feed grade biuret to furnish one-half of the total protein equivalent produced very satisfactory results. The average performance of cows on these products was not as good as that of cows fed natural protein supplements, but was much better than performance of range cattle fed supplements containing non-protein-nitrogen in past research at the Oklahoma Experiment Station. The improved performance may be due to self-feeding, or improved supplement formulation, or both.

Comparison of Cottonseed Hulls and Wheat Straw as a Roughage Ingredient in Steer Finishing Rations

R. R. Frahm, D. G. Wagoner, D. F. Stephens and R. E. Renbarger

Story in Brief

Data were analyzed from 87 choice Angus steers involved in a 196 day feedlot trial involving two rations that differed only with regard to a roughage ingredient. One ratio contained 15 percent cottonseed hulls and the other contained 15 percent wheat straw. The feedlot performance and carcass data were essentially the same for both rations which suggests that wheat straw can be successfully utilized in a finishing ration and should be considered when it is economically advantageous to do so.

Introduction

Cattle finishing rations commonly contain some roughage ingredient which can, in some circumstances, be an expensive feed item. Many Oklahoma farms have available sources of roughage. The use of these roughages in cattle finishing rations could result in some economic advantage providing they are as effective in the ration as the conventional roughages purchased from sources off the farm. The purpose of this study was to evaluate a readily available roughage on many Oklahoma farms, wheat straw, as a roughage replacement for a commonly purchased roughage for finishing rations, cottonseed hulls.

In cooperation with Ft. Reno Livestock Research Station, Agriculture Research Service, Animal Science Research Division, USDA.

Materials and Methods

A 196-day feeding trial was conducted to compare wheat straw and cottonseed hulls as roughage ingredients of finishing rations. The 94 choice Angus steers initially allotted to this experiment were the progeny of 10 sires involved in a progeny testing program as a part of the beef cattle breeding project. In order to maintain valid progeny test comparisons between sires, half of each sire group was allotted to each treatment group. Within this restriction, the steers were allotted to each treatment group such that their acual weaning weights were equalized (440 lbs. for both groups). The steers were weaned at an average of 205 days at the Lake Carl Blackwell range and were transported to the Ft. Reno Livestock Research Station where they were placed on feed test two weeks after weaning. The steers were fed in two adjoining pens that opened to the south from a feeding barn. An outbreak of respiratory disease was experienced with these steers and data from those animals that became extremely sick in addition to those that died were excluded from the analysis (4 from the cottonseed hull ration and 3 from the wheat straw ration).

The composition of the rations is presented in Table 1. These rations have a higher roughage content than most conventional finishing rations simply because the cottonseed hull ration was formulated for use in measuring postweaning feedlot performance for bulls raised in the beef cattle selection study being conducted at Ft. Reno. The only difference in

Table 1. Composition of Rations.[1]

Ingredient	Amount in Percent	
	Cottonseed Hull Ration	Wheat Straw Ration
Shelled corn	32.5	32.5
Oats	20.0	20.0
Cottonseed hulls	15.0	0
Wheat straw	0	15.0
Alfalfa	15.0	15.0
Soybean meal (44%)	12.5	12.5
Molasses	5.0	5.0
Chemical Analysis (%)[2]		
Dry matter	89.5	89.6
Crude protein	13.5	13.7
Acid detergent fiber	20.2**	17.2**
Ether extract	2.7	2.9

[1] In addition both rations had 10 lbs. of salt and 5 lbs. of aurofac-10 added per ton and mineral salt and bone meal was provided *ad lib.*
[2] Average determination from 17 samples obtained of each ration over the feeding period. Chemical composition presented on an as is basis.
**Treatment means different at the 0.01 probability level.

the formulation of these two rations was the replacement of cottonseed hulls by wheat straw. The rations were ground through a 3/8 inch screen and fed to the steers in self feeders. The only difference in the chemical composition detected in the two rations was the 3 percent higher ($P < 0.01$) acid detergent fiber content of the cottonseed hull ration.

Results and Discussion

The feedlot performance and carcass data of the steers in the cottonseed hull and wheat straw rations are presented in Table 2. The initial weights were determined at the start of the feeding trial two weeks after the steers were weaned. They differ slightly for the two treatments because the initial allotment to treatment groups was based on weaning weights along with the fact that data on 7 steers were eliminated from the analysis because of sickness or death.

The most striking result of this study was that all of the feedlot performance and carcass traits measured were clearly not significantly different between the two treatments. It should be emphasized that the number of animals involved and the design of this study were such that relatively small differences in performance could have been detected had they existed.

No particular difficulties were encountered from using wheat straw in the ration. There appeared to be a slight tendency for the steers on

Table 2. Feedlot Performance and Carcass Information (196 days).[1]

Trait Measured	Cotonseed hull ration	Wheat straw ration
No. steers	43	44
Feedlot data:		
Initial weight, lbs.	432	428
Final weight, lbs.	846	834
Daily gain, lbs.	2.11	2.07
Feed/lb. gain, lbs.	8.21	7.91
Carcass data:		
Hot carcass weight, lbs.	542	531
Dressing percent	64.1	63.7
Carcass grade[2]	10.4	10.4
Ribeye area, sq. in.	10.4	10.2
Fat thickness, in.	0.81	0.79
Marbling score[3]	5.1	5.3
Cutability, °10[4]	49.2	49.3

[1] None of the differences in performance from these rations were significant ($P \leq 0.05$).
[2] U.S.D.A. carcass grades converted to the following numerical designations: high choice-12, avg. choice-11, low choice-10, high good-9.
[3] Marbling score equivalents: moderate-7, modest-6, small-5, slight-4.
[4] Estimated percentage boneless retail cuts from round, loin, rib and chuck.

wheat straw to look fuller; however, an increase in incidence of bloat was not observed.

Results from this study suggest that wheat straw can be successfully utilized as a roughage in finishing rations and should be considered when available at a price below that of cottonseed hulls or other similar roughages.

A Comparison of Corn Processing Methods, Several Levels of Corn Silage, and Sorghum Stover Silage versus Corn Silage for Finishing Steers

Jerry Martin[2], Raymond Peck[2], Milton England[2], Jack Alexander[2], and Robert Totusek[3]

Story In Brief

Three methods of processing corn were compared. High-moisture-harvested ground corn and ground-reconstituted corn were utilized 11.0 and 6.5 percent more efficiently than dry ground corn.

A ration containing 20 percent corn silage did not produce faster gains but was utilized 14.5 percent more efficiently than a ration containing 20 percent sorghum stover silage.

Rations containing 20 and 50 percent corn silage were similar in terms of cost of gain and carcass grade, but the 20 percent silage ration had an advantage in rate and efficiency of gain. An 80 percent silage ration produced economical gains, but carcass grades indicated a longer feeding period would have been desirable.

[1]Experiment conducted at Panhandle State College, Goodwell.
[2]Panhandle State College, Goodwell.
[3]Oklahoma State University, Stillwater

Introduction

Corn silage is fed in significant quantity to feedlot cattle in irrigated areas of the Southwest. The percentage fed varies with the feedlot stage of the cattle and with other factors but the amount of corn silage used varies from as much as 80 percent to as little as 5 to 10 percent of the ration. The usual practice is to rapidly decrease the percentage of corn silage in the ration to a very low level for the major portion of the feeding period. Information is needed concerning the value of modern rations containing widely different levels of silage throughout the feeding period.

Although much of the irrigated corn acreage is utilized for corn silage production, an increasing acreage is being used each year for corn grain production. Under the proper management it is considered to be very competitive with the irrigated grain sorghums. Considering this trend to increased production and feeding of corn grain, it is important to evaluate the different methods available for harvesting and preparing corn grain for feedlot cattle so that the greatest yields of beef can be obtained per acre of corn produced. Furthermore, most corn in the Southwest is irrigated, and it is imperative to make the most efficient possible use of this depletable resource.

Materials and Methods

Eighty-nine head of yearling steers were used in this study to determine:

1. The feeding value of ground dry corn, high-moisture-harvested ground corn, and ground-reconstituted corn.
2. The net value of rations containing widely different levels of corn silage.
3. The feeding value of sorghum fodder silage compared to corn silage.

Using weight and grade as the criteria, five steers were selected from the group for the purpose of obtaining initial body composition data. The remaining 84 steers were divided by weight into 12 groups of seven steers each. These 12 groups were divided into two replications of six groups each and the groups within replication assigned at random to one of six ration treatments. The ration treatments are shown below.

(1) Dry ground corn + 20 percent sorghum stover silage[1] + protein supplement.

(2) Dry ground corn + 20 percent corn silage[1] + protein supplement.

(3) Dry ground corn + 50 percent corn silage[1] + protein supplement.

[1]Percent of the daily dry matter intake of the steers.

(4) Dry ground corn + 80 percent corn silage[1] + protein supplement.
(5) High-moisture-harvested ground corn + 20 percent corn silage[1] + protein supplement.
(6) Ground-reconstituted corn + 20 percent corn silage[1] + protein supplement.

The ingredient makeup of the protein supplement, fed at a level of 1.5 pounds per steer daily, is shown in Table 1. Each steer received two 15 mg. stilbestrol implants at the beginning of the trial.

With the exception of the corn used in combination with the sorghum stover silage (Treatment 1), the corn used in all ration treatments was produced from the same field. The high-moisture-harvested corn was harvested when the moisture content of the grain was approximately 30 percent. The remaining corn was allowed to dry in the field to a moisture content of about 15 percent and harvested to provide corn used for the dry and reconstituted corn treatments. The high-moisture-harvested corn was ground and ensiled in a small concrete-lined trench silo. The reconstituted corn was prepared by grinding the corn and then adding water to the ground grain as it was augered into the silo for ensiling. The dry corn was ground as needed. All grains were ground with a hammermill utilizing a one-fourth inch screen. All of the corn silage used in the study came from the same field and was stored in one silo. Samples of the feed constituting the different treatments were collected periodically during the study for dry matter determinations and proximate analysis. The average moisture content of feeds is shown in Table 2.

At the end of a 117-day feeding period, all steers were slaughtered and specific gravity determinations were made. Carcass data obtained included quality grade, loin eye area, fat thickness over the loin eye, and percent kidney and pelvic fat.

Table 1. Ingredient Makeup of Supplement

Ingredient	Percent of mix
Soybean meal (44%)	40.0
Dehydrated alfalfa meal (17%)	35.0
Urea (45% nitrogen)	10.0
Stock salt	5.0
Dicalcium phosphate	2.0
Calcium carbonate	6.0
Premix[1]	1.2
Aurofac 10	0.8
	100.0

[1] Source of Vitamins A, D, and E.

Table 2. Percent Moisture of Feeds[1]

	High moisture harvested corn	Reconstituted corn	Dry corn	Corn silage	Sorghum stover silage
Moisture, %	29.21	32.26	16.15	63.81	58.19

[1] Each value based on 16 samples taken at regular intervals during the feeding period.

Results and Discussion

The performance data for the 117-day feeding trial is shown in Table 3.

Average daily gain for the steers fed corn processed by different methods was very similar. The cattle fed high-moisture-harvested corn consumed less air dry feed than the cattle fed dry corn and were 11.0 percent more efficient than the latter group. This is in agreement with previous work with high-moisture-harvested corn at this station.

The efficiency of gain on reconstituted corn was 4.8 percent poorer than on the high-moisture-harvested corn but 6.5 percent better than on dry corn. Previous research at this station has similarly shown that grinding milo previous to reconstitution is less effective than reconstituting the whole grain or high-moisture-harvesting.

Using the feed prices shown in Table 3, the high-moisture-harvested corn produced the most economical gains followed by reconstituted and dry corns.

The steers fed 20 percent corn silage gained only 0.13 pounds more per day than those fed 20 percent sorghum silage but were considerably more efficient and economical in their feed utilization. There was also a difference in quality grade (Table 4) in favor of the corn silage fed steers. Only 50 percent of the steers fed sorghum stover silage graded choice while 85.7 percent of the steers fed corn silage graded choice. In previous trials there has been little difference between dry sorghum stover and corn silage when fed at 20 percent of the ration dry matter. Perhaps a low quality of roughage is more effective in a dry form. However, the quality of the sorghum stover silage used in this trial was rather poor.

Steer gains tended to decrease as the level of silage increased, especially at the 80 percent silage level. However, gains were respectable considering the lower quantities of corn grain consumed. Feed intake was greatest for the 50 percent silage group and lowest for steers fed 80 percent silage. Feed efficiency was best for the 20 percent silage treatment and similar for the 50 and 80 percent silage groups. The equal values for efficiency of gain between the 80 and 50 percent corn silage groups is somewhat misleading as indicated by the average quality grade (Table 4)

Table 3. Feedlot Performance Data (117 Days)

	Dry ground corn, 20% sorghum stover silage	Dry ground corn, 20% corn silage	Dry ground corn, 50% corn silage	Dry ground corn, 80% corn silage	High-moisture harvested ground corn, 20% corn silage	Ground reconstituted corn, 20% corn silage
No. steers	14	14	14	14	14	14
Initial wt., lb.	776	776	776	778	778	780
Final wt., lb.	1122	1138	1118	1069	1130	1122
Daily gain, lb.	2.96	3.09	2.92	2.49	3.02	2.92
Daily feed intake, lb.[1]						
Corn	19.68	16.77	11.02	2.59	14.42	14.63
Silage	4.83	4.99	12.92	17.58	4.27	4.44
Supplement	1.50	1.50	1.50	1.50	1.50	1.50
Total	26.01	23.26	25.44	21.67	20.19	20.57
Feed/lb. gain, lb.[1]	8.82	7.54[2]	8.73	8.70	6.71[3]	7.05[4]
Feed cost/cwt. gain, $[5]	20.28	17.79	17.27	13.64	16.07	16.82

[1] All values expressed on 90% dry matter basis.
[2] 14.5 percent more efficient than sorghum stover silage.
[3] 11.0 percent more efficient than dry corn.
4.8 percent more efficient than reconstituted corn.
[4] 6.5 percent more efficient than dry corn.
[5] Feed Prices

Dry ground corn	$ 2.40/cwt.	Corn silage	$10/ton
High-moisture-harvested ground corn	2.05/cwt.	Sorghum Stover Silage	7/ton
Ground-reconstituted corn	1.96/cwt.	Protein Supplement	3.67/ton

Price of grains and supplement includes $ .15/cwt. processing and mixing charge.

Table 4. Carcass Data

	Dry ground corn, 20% sorghum stover silage	Dry ground corn, 20% corn silage	Dry ground corn, 50% corn silage	Dry ground corn, 80% corn silage	High-moisture harvested ground corn, 20% corn silage	Ground reconstituted corn, 20% corn silage
No. Steers	14	14	14	14	14	14
Final live wt., lb.	1122	1138	1118	1069	1130	1122
Hot carcass wt., lb.	708	719	714	666	712	716
Chilled carcass wt., lb.	695	706	702	656	706	703
Dressing percent	63.1	63.2	63.9	62.3	63.0	63.8
Quality grade						
No. choice	7	12	12	9	11	12
No. good	7	2	2	5	3	2
Percent choice	50.0	85.7	85.7	64.3	78.6	85.7

of the two groups. Approximately 86 percent of the carcasses from the 50 percent corn silage group graded choice while only about 64 percent of those from the 80 percent corn silage group graded choice. This would tend to indicate that 50 percent corn silage steers were fatter. The 80 percent silage steers undoubtedly needed a longer feeding period. It is interesting to note that the 50 percent silage steers graded as well as the 20 percent silage group and made slightly cheaper gains. The gains of the 80 percent silage group were very economical, but the cattle obviously were not finished.

The net energy values of feeds compared in this trial will be reported later.

Whole Corn vs. Ground Corn vs. Rolled Corn For Finishing Cattle[1]

Jerry Martin[2], Milton England[2], Jack Alexander[2], Ted Montgomery[2], Donald G. Wagner[3] and Robert Totusek[3]

Story In Brief

Whole corn, ground corn, and rolled corn were compared in feedlot rations for steers using sorghum silage as the roughage source and a conventional supplement. During a 140-day feeding trial, differences in rate of gain and feed efficiency were small. Steers fed either the ground or rolled corn consumed one pound more air-dry feed daily than those fed whole corn but were no more efficient in their feed utilization.

The feed cost of grain was lowest for the steers receiving the whole corn due primarily to no processing cost charges against whole corn. The lower cost of gain for the whole corn resulted in a cost advantage of $6.80 and $3.60 compared to rolled and ground corn, respectively.

Introduction

The cost of grain processing for finishing cattle is always of major concern to the cattle feeder, since a small reduction in feed processing

[1]Experiment conducted at Panhandle State College, Goodwell.
[2]Panhandle State College, Goodwell.
[3]Oklahoma State University, Stillwater

cost can significantly increase net returns, particularly for the larger feeder. Some feedlots in the Texas-Oklahoma Panhandle and Southwest Kansas area have utilized whole corn with varying degrees of success. In most cases, the use of whole corn has been in high concentrate rations using a special supplement.

The purpose of this trial was to compare whole corn with ground and rolled corn when used with sorghum silage and a conventional protein-mineral supplement.

Materials and Methods

Eighty-four yearling steers were grouped according to weight into 12 groups of seven steers each. These groups were then divided into four replications of three groups each and the groups within replications allotted randomly to the following ration treatments.

(1) Ground yellow corn + sorghum silage + supplement.
(2) Rolled yellow corn + sorghum silage + supplement.
(3) Whole yellow corn + sorghum silage + supplement.

There were four lots of seven steers per lot on each treatment, a total of 28 steers per treatment.

The initial and final weights of the steers were taken after a 16-hour shrink off feed and water. At the end of the 140 day feeding period, the steers were slaughtered and carcass data collected.

The grain used in the study was purchased from a local grain elevator in ten-ton lots with portions of each lot being ground and rolled for the respective corn preparation treatments. The sorghum silage was purchased from a area farmer. Samples of the grain and silage were collected periodically during the study for the purpose of dry matter determinations, particle size measurements, and density measurements.

The sorghum silage was fed at a level to constitute approximately 20 percent of the daily dry matter intake of the steers. The steers were fed twice daily to appetite.

All steers were implanted with two 15 mg. stilbestrol implants at the beginning of the feeding period.

Results and Discussion

The protein-mineral-vitamin supplement used in this study is shown in Table 1. This supplement was fed at a level of 1.7 pounds per steer per day.

The results shown in Table 3 indicate very little difference in performance of cattle fed corn processed by the three methods. Both rate of gain and feed conversion values were very similar among treatment

Table 1. Ingredient Makeup of Supplement

Ingredient	Percent of Mix
Cottonseed meal (43%)	40.0
Dehydrated alfalfa meal (17%)	35.0
Urea (45% nitrogen)	10.0
Stock salt	5.0
Dicalcium phosphate	2.0
Calcium carbonate	6.0
Premix[1]	1.2
Aurofac 10	0.8
	100.0

[1] Source of Vitamin A, D, and E.

Table 2. Moisture, Particle Size, and Density of Processed Corn

Process	Screen Size				Moisture percent	Weight per bushel
	4.0mm	3.0mm	2.0mm	1.0mm		
	Percent passing through					lb.
Whole corn	0	0	0	0	14.16	55.6
Whole corn	17.24	0	0	0	13.90	46.5
Ground corn	99.06	75.11	52.70	17.24	13.86	44.9

groups and apparently were influenced very little by the methods or processing corn compared in this experiment.

A physical separation of the fecal material from steers fed whole corn showed many whole kernels of corn passed through the digestive tract. This was probably true with ground and rolled corn also as indicated by the feed efficiency values of these groups but the undigested corn in their fecal material was simply less obvious.

It was more difficult to keep the steers receiving whole corn on feed as compared to the other two groups. The steers on whole corn tended to select the roughage at each feeding and as indicated in Table 3 consumed one pound less air-dry feed, mostly corn, then the steers fed ground and rolled corn.

Using the indicated feed prices shown in Table 3 and a charge of $0.15 per cwt. for grinding and rolling, the steers fed whole corn produced the most economical gains. This amounted to a cost reduction of $6.80 and $3.60 compared to rolled and ground corn, respectively, based on a feedlot gain of 400 pounds per steer.

Method of corn preparation had no effect on carcass merit (Table 4). There were no apparent differences in any of the carcass characteristics measured.

Table 3. Feedlot Performance Data (140 Days)

	Ground corn	Rolled corn	Whole corn
No. Steer	28	27	28
Initial wt., lb.[1]	651	649	649
140 day wt., lb.[1]	1072	1056	1053
Daily gain, lb.	3.01	2.91	2.88
Daily feed intake, lb.[2]			
Grain	17.2	17.2	16.4
Sorghum silage	4.6	4.6	4.4
Protein supplement	1.7	1.7	1.7
Total	23.5	23.5	22.5
Feed[2]/lb. gain, lb.	7.80	8.08	7.78
Feed cost/cwt. gain, $[3]	21.61	22.41	20.71

[1] Based on 14 hour shrink off feed and water.
[2] Values expressed on 90% dry matter basis.
[3] Feed Prices

Whole corn	$2.80/cwt.	Protein supplement	$3.45/cwt.
Ground corn	2.95/cwt.		
Rolled corn	2.95/cwt.	Price of ground and rolled corn includes $ .15/cwt. processing charge.	
Sorghum silage	7.00/ton		

Table 4. Carcass Data

	Ground corn	Rolled corn	Whole corn
No. Steers	28	27	28
Final live wt., lb.	1072	1056	1053
Hot carcass wt., lb.	697	693	687
Dressing percent[1]	65.0	65.6	65.2
Carcass grade[2]	10.0	10.5	10.5
Ribeye area, sq. in.[3]	11.7	11.6	11.3
Fat thickness, in.[4]	.51	.59	.57
Cutability, %[5]	48.9	48.5	48.4

[1] Calculated on basis of live shrunk weight and hot carcass weight.
[2] U.S.D.A. grading standard: high choice–12, average choice–11, low choice–10, high good–9.
[3] Surface area of loin eye at 12th rib.
[4] Average of three measurements taken on ribeye tracing at 12th rib.
[5] Percent of boneless trimmed retail cuts on carcass basis = 51.34 – 5.78 (fat thickness) – .462 (% kidney fat) + .740 (ribeye area) – .0093 (chilled carcass weight).

Influence of Level of Wheat in High Concentrate Rations on The Performance of Fattening Beef Cattle

Donald G. Wagner, Ryan Christiansen and Robert Renbarger

Story in Brief

Various levels of wheat were compared in high concentrate (90 percent) rations for fattening beef cattle. The treatments studied were 1) dry milo (no wheat) 2) 42 percent wheat (½ of cereal grain in ration) 3) 63 percent wheat (¾ of the cereal grain in ration) and 4) 84 percent wheat (100 percent of cereal grain in ration).

The average daily gains were 2.56, 2.77, 2.86 and 2.38 lb. on the milo, 42 percent wheat, 63 percent wheat and 84 percent wheat treatments respectively, ($P>.05$). One heifer on the 84 percent wheat treatment was condemmed for ascites at the time of slaughter and gained only .67 lb. per day during the experiment. Removal of this animal from the average reported above, resulted in an average of 2.54 lb. per day for the remaining heifers on the 84 percent wheat ration. The average feed required per pound of gain was 7.46, 6.88, 6.68 and 7.59 lb. on the milo, 42 percent wheat, 63 percent wheat and 84 percent wheat treatments, respectively ($P>.05$). This experiment would suggest that substantially higher levels of wheat can be successfully used than are normally used in high concentrate feedlot rations when accompanied by good management.

Introduction

Wheat represents a very important economic crop in Oklahoma. Due to the low wheat prices during the past few years, wheat has been competitively priced with other cereal grains as livestock feed. Therefore, considerable quantities of wheat are currently being fed in Oklahoma, particularly in beef cattle and swine rations.

Much of the previous work with feeding of wheat to fattening beef cattle was conducted some years ago in which wheat was fed in more conventional, much higher roughage rations than now used throughout much of the high plains cattle feeding area. Rations containing as much as 90 percent or more concentrates are now commonly fed in many feedlots.

In cooperation with Agricultural Research Service, Animal Science Division, USDA.

Very little work has been conducted to investigate the use of various amounts of wheat in such rations. Many feedlots would find it economically advantageous for them to use the maximum amount of wheat possible compatible with obtaining satisfactory animal performance. Previous reports and some field observations suggest that high levels of wheat in fattening rations frequently depress feed intakes and gains. If wheat is fed, feedlot rations commonly contain a maximum of 30-40 percent wheat; often, much less is included. The objective of this experiment, therefore was to determine the effect of various levels of wheat in high concentrate rations when fed to fattening beef cattle.

Materials and Methods

Choice Angus yearling feeder heifers, varying from about 525-625 pounds, were selected for use in this feeding experiment. The animals were gradually adapted to a high concentrate ration during a three week preliminary period.

Following the preliminary period, 48 heifers were selected and blocked into three groups on the basis of weight and then randomly allotted within blocks to four treatments with four heifers per pen (12 animals per treatment). The treatments studied were as follows:

1) milo (0 percent wheat)
2) wheat — 42 percent in total ration (50 percent of cereal grain)
3) wheat — 63 percent in total ration (75 percent of cereal grain)
4) wheat — 84 percent in total ration (100 percent of cereal grain)

The compositions of the rations are given in Table 1.

The wheat in this experiment was of the Triumph variety which is a hard red winter wheat. In the rations containing 42 and 63 percent wheat, dry rolled milo constituted the remainder of the cereal grain portion. In all four treatments, both the milo and wheat were dry rolled through an 18 x 24″ heavy duty roller mill. The rations were all formulated to contain the composition indicated on a 90 percent DM basis. The

Table 1. Ration Composition[1]

	Milo	Wheat		
		42	63	84
	%			
Milo	84	42	21	--
Wheat	--	42	63	84
Premix[2]	16	16	16	16

[1] Formulated on a 90% D.M. basis.
[2] Contained cottonseed hulls, ground alfalfa hay, soybean meal, urea, minerals, antibiotics and vitamin A.

rations were 90 percent concentrate—10 percent roughage mixtures using 5 percent cottonseed hulls and 5 percent ground alfalfa hay as the source of roughage. The rations were fed in self feeders in quantities adequate to last for approximately five days. All animals were implanted with 24 mg of stilbestrol at the beginning of the experiment.

The heifers in the two heaviest blocks were fed for 104 days prior to slaughter; whereas, the heifers in the light weight block were fed for 140 days, giving an overall average feeding time of 116 days for all heifers. Initial and final weights were taken after a 16 hour overnight shrink off feed and water.

Feed samples were collected periodically for analysis.

Results and Discussion

The feedlot performance data are given in Table 3. As noted, feed intakes were quite uniform among all treatments ($P>.05$), although slightly lower on the all wheat ration. Average daily gains were 2.56, 2.77, 2.86 and 2.38 lb. on the milo, 42 percent wheat, 63 percent wheat and 84

Table 2. Proximate Analysis of Wheat and Milo

Feed	Dry Matter	Crude[1] Protein	Ash[1]	Ether[1] Extract	Carbohydrates[1 2]
			%		
Milo	88.1	9.86	1.63	2.34	86.17
Wheat	89.6	15.07	2.23	1.17	81.53

[1] Expressed on a DM basis
[2] 100 — (Sum of figures for crude protein, ash and ether extract)

Table 3. Feedlot Performance

	Milo	Wheat (Percent) 42	63	84
No. of heifers	12	12	12	12
Initial weight, lb.	591	585	587	596
Final weight, lb.	885	901	912	870
Daily feed, lb.[1 2]	19.1	19.0	19.0	18.0
Daily gain, lb.[2]	2.56	2.77	2.86	2.38[3] 2.54[4]
Feed/lb. gain, lb.[2]	7.46	6.88	6.68	7.59[3] 7.39[4]

[1] Expressed on a 90% DM basis
[2] None of the values indicated were significantly different at the .05 level of probability
[3] Includes all 12 heifers in the treatment
[4] Excludes one heifer which was condemned for ascites at the time of slaughter and which gained 0.67 lb. per day during the experiment.

Table 4. Slaughter and Carcass Information

	Dry Rolled Milo	Wheat (Percent)		
		42	63	84
Dressing percent[1]	62.2	62.2	61.0	69.8
Carcass grade[2]	11.1	10.5	9.9	10.0
Rib eye area, sq. in.	11.9	11.8	11.8	11.1
Fat thickness in.[3]	0.91	0.98	0.90	0.86
Marbling[4]	20.0	18.1	16.8	17.3

[1] Calculated on basis of live shrunk weight and chilled carcass weight.
[2] U.S.D.A. carcass grade converted to following numeral 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.
[5] None of the carcass traits differed significantly at the .05 level of probability.

percent wheat rations, respectively ($P>.05$). One of the 12 heifers on the 84 percent wheat ration gained only 0.67 lb. per day and was condemned for ascites at the time of slaughter, the cause of which was unknown. This is one possible reason the average daily gain was lower on the 84 percent wheat treatment. The average gains of the remaining 11 heifers on the 84 percent wheat ration was 2.54 lb. per day, equally as good as for the all milo ration but somewhat less than for the wheat—milo mixed rations.

The average feed required per pound of gain was 7.46, 6.88, 6.68 and 7.59 lb. on the milo, 42 percent wheat, 63 percent wheat and 84 percent wheat treatments, respectively ($P>.05$). Assigning an estimated NE_m value of 83 Mcal and an estimated NE_g value of 53 Mcal/100 lb. to the 84 percent wheat ration, together with the use of net energy requirement values for maintenance and gain, it might be possible to estimate within limits the quantity of feed consumed during the experiment by the animal condemned for ascites. While such an assumption would be subject to some question when estimating the feed consumption of a sick animal, such a correction would produce an estimated feed conversion of 7.39 lb. of feed per lb. of gain for the remaining animals on the 84 percent wheat ration as contrasted with an uncorrected value of 7.54 lb. of feed/lb. of gain. Nevertheless, no statistically significant differences ($P>.05$) existed in feed efficiency in either case.

Although not statistically significant, the slightly higher feed conversion values reported on the two mixed milo rations were probably, in part, functions of the slightly greater daily gains on these rations, since it is a well known fact that faster rates of gain usually produce improved feed conversions (lb. feed/lb. gain) in fattening cattle. Volatile fatty acid and lactic acid productions are also being determined on such rations.

In brief, this experiment would also suggest that substantially higher

levels of wheat could be very successfully used in many high concentrate feedlot rations than is now the case, providing satisfactory management is employed. It is a known research fact that wheat may be prone to inducing a lower rumen pH and more acidosis than some other cereal grains in some circumstances.

Influence Of Level Of Wheat And Method Of Processing Wheat On The Performance Of Fattening Beef Cattle

Donald G. Wagner, Ryan Christiansen, Wilburn Holloway and Robert Renbarger

Story in Brief

Two methods of processing wheat, fine grinding and dry rolling, and two levels of wheat, 40 percent wheat and 70 percent wheat, were compared with dry rolled milo in high concentrate rations for fattening beef cattle. The treatments investigated in a 90 percent concentrate ration were 1) dry rolled milo, 2) rolled wheat—40 percent wheat in the total ration, 3) rolled wheat—70 percent in the total ration, 4) finely ground wheat—40 percent wheat in the total ration and 5) finely ground wheat —70 percent wheat in the total ration.

In a 140 day feeding experiment, average daily feed intakes on a 90 percent D.M. basis were 19.1, 17.5, 17.0, 18.7 and 18.6 lb. for the dry rolled milo, rolled—40 percent wheat, rolled—70 percent wheat, ground—40 percent wheat and ground—70 percent wheat treatments, respectively. Average gains were 3.11, 2.91, 2.81, 2.97 and 2.85 lb. per day, and the pounds of feed required per pound of gain were 6.15, 6.09, 6.08, 6.35 and 6.54 for the same treatments, respectively. The values reported for average daily feed intakes, gains and feed conversions were not statistically significant ($P<.05$).

In cooperation with Agricultural Research Service, Animal Science Division, USDA.

Introduction

Most research on the utilization of feed grains by fattening cattle has been conducted with corn and to a lesser extent with milo. Very limited work has been done with wheat in recent years. Wheat represents a major economic crop in Oklahoma. Wheat prices have usually been too high during most recent periods in history to permit wheat to be used extensively as livestock feed. During the past two years, however, wheat has been very competitively priced with other grains as an energy source for fattening cattle. Furthermore, high yielding varieties of wheat have also been developed in recent years. Some of these varieties have poor milling and baking properties, but they could possibly be used as livestock feed.

Little or no research has been conducted to determine the best methods of processing wheat when fed in high concentrate rations to fattening cattle. Furthermore, very little information is currently available concerning the effects of feeding different levels of wheat in high concentrate type rations now being widely used in the feedlot industry. The objective of this experiment, therefore, was to determine the value of dry rolled versus finely ground wheat when each was fed at either 40 to 70 percent of the total ration in high concentrate feedlot rations.

Materials and Methods

Equal numbers of Choice Angus and Hereford feeder steers, weighing approximately 600 pounds, were selected for use in the feeding experiment. The steers were gradually adapted to a 90 percent concentrate ration during a three week preliminary period by gradually decreasing the quantity of roughage in the ration.

Following the preliminary period, the steers were blocked into four groups on the basis of breed and weight. A slaughter sample was selected at random from each block to permit net energy values of the ration to be determined using the comparative slaughter technique. The 72 remaining steers were then randomly allotted within blocks to five treatments with three steers per pen (12 animals per treatment). The five treatments were as follows:

1) Dry rolled milo
2) Dry rolled wheat—40 percent in total ration
3) Dry rolled wheat—70 percent wheat in total ration
4) Finely ground wheat—40 percent wheat in total ration
5) Finely ground wheat—70 percent wheat in total ration

The dry rolled milo and wheat were obtained by rolling the grain through a heavy duty 18 x 24" roller mill with a roller spacing of .003 inch. The finely ground wheat was obtained by grinding the wheat

through 1/8" hammermill screen. The wheat was of the Triumph variety, a hard red winter wheat.

The experimental rations consisted of a 90 percent concentrate mixture, formulated on a 90 percent dry matter basis as shown in Table 1. The ration ingredients other than milo or wheat were combined in a premix. The complete ration contained 5 percent cottonseed hulls and 5 percent ground alfalfa hay to produce a 90 percent concentrate—10 percent roughage ration. The milo which was included in the 40 and 70 percent wheat rations (Table 1) was dry rolled. Feed was prepared and fed daily in amounts which would permit availability of feed until the next feeding. Stilbestrol was implanted at the 24 mg level at the initiation of the feeding trial and again after 84 days on feed. The feeding period lasted for 140 days. Initial and final weights were taken after a 16 hour shrink off feed and water.

Results and Discussion

The proximate analysis data for the wheat and milo are presented in Table 2 and the particle size and density data for the wheat in Table 3. As noted in Table 3, the particle size and weights per bushel were quite different for the dry rolled versus the finely ground wheat treatments.

Table 1. Ration Composition[1]

Ingredient	Dry Rolled Milo	Rolled Wheat		Ground Wheat	
		40% Wheat	70% Wheat	40% Wheat	70% Wheat
			%		
Wheat	--	40.0	70.0	40.0	70.0
Milo	84.0	44.0	14.0	44.0	14.0
Premix[2]	16.0	16.0	16.0	16.0	16.0

[1] Formulated on a 90% D.M. basis.
[2] Contained cottonseed hulls, ground alfalfa hay, soybean meal, urea, minerals, antibiotics and Vitamin A.

Table 2. Proximate Analysis of Milo and Wheat

Feed	Dry Matter	Crude Protein	Ash[1]	Ether Extract	Carbo-[1 2] hydrates
			%		
Milo	87.0	11.0	1.50	2.00	85.5
Wheat	88.0	12.9	1.95	1.55	83.6

[1] Values expressed on a D.M. basis.
[2] 100 — (Sum of figures for crude protein, ash and ether extract).

Table 3. Particle Size and Density of Processed Wheat

	Screen Size							
	4 mm	2 mm	1 mm	500 micron	250 micron	125 micron	125 micron	Wt. per bu.
	% Retained on Screen						through	lb.
Fine grind (1/8" screen)	0	1.6	32.8	32.6	18.4	10.4	4.2	49
Dry rolled	3.1	48.7	26.8	10.6	6.6	2.8	1.4	32

The feedlot performance data are presented in Table 4. As noted the average daily feed intakes during the 140 day feeding period were 19.1, 17.5, 17.0, 18.7 and 18.6 pounds per day for the dry rolled milo, rolled—40 percent wheat, rolled—70 percent wheat, finely ground—40 percent wheat and finely ground—70 percent wheat treatments, respectively. Average gains were 3.11, 2.91, 2.81, 2.97 and 2.85 pounds per day, and the lb. of feed/lb. gain were 6.15, 6.09, 6.08, 6.35, and 6.54 for the same treatments, respectively. The above values for daily gain, feed intake and feed/pound of gain were not significantly different ($P<.05$) among treatments. Net energy values using the comparative slaughter techniques are also being determined for each of the treatments.

In comparing the performance of cattle on the rolled wheat versus ground wheat treatments, however, the 24 cattle (8 pens) on rolled wheat (treatments 2 and 3) required 6.08 lb. of feed/lb. of gain as contrasted with 6.44 lb. of feed/lb. of gain for the 24 cattle on ground wheat (treatments 4 and 5). This represents a difference of 5.9 percent in feed efficiency. Considering that an average of 55 percent of the total ration was

Table 4. Feedlot Performance (140 Days)

	Dry Rolled Milo	Rolled Wheat		Ground Wheat	
		40%	70%	40%	70%
No. of steers	12	12	12	12	12
Initial weight, lb.	609	596	600	604	620
Final weight, lb.	1044	1003	994	1019	1019
Daily feed, lb.[1,2]	19.1	17.5	17.0	18.7	18.6
Daily gain, lb.[2]	3.11	2.91	2.81	2.97	2.85
Feed/lb. gain, lb.[2]	6.15	6.09	6.08	6.34	6.54

[1] Expressed on a 90% D.M. basis.
[2] None of the values for feed intake, gain or feed per lb. of gain were significantly different at the .05 level of probability.

wheat (40 + 70/2=55) in comparing the main effects of grinding vs. rolling in this instance (remaining components of the rations were identical in both cases), the data would suggest that rolling improved the utilization of the wheat component by an average of 10.6 percent (5.9/55 = 10.6) over grinding in this experiment. While this may seem like a small amount, this represents about the same magnitude of increase in feed efficiency which is frequently expected by proper steam flaking, reconstitution and the like of milo grain as contrasted with rolling or fine grinding of milo for fattening beef cattle. Rolling of wheat would, therefore, appear to be superior to grinding as a processing technique on the basis of the values indicated above. However, further research is needed to support or refute the above observation before valid conclusions can be drawn.

In comparing levels of wheat in the ration, irregardless of method of processing, the 40 percent wheat ration produced average daily feed intake, gain and feed conversion values of 18.1, 2.94, and 6.22, respectively as compared with values of 17.8, 2.83 and 6.31 respectively for the 70 percent wheat rations. The results of this experiment would suggest that much higher levels of wheat can be satisfactorily used in feedlot rations than are commonly fed in the industry without serious deterioration of feedlot performance if good management is practiced.

As noted in Table 5, no significant differences ($P<.05$) were obtained for any of the carcass traits.

Table 5. Slaughter and Carcass Information

	Dry Rolled Milo	Rolled Wheat		Ground Wheat	
		40%	70%	40%	70%
Dressing %[1,5]	60.8	60.4	60.2	60.8	60.4
Carcass grade[2,5]	10.8	10.5	11.1	11.6	11.3
Ribeye area,[5] sq. in.	12.1	11.7	11.6	11.9	11.5
Fat thickness, in.[3,5]	0.8	0.7	0.8	0.8	0.8
Marbling[4,5]	16.7	15.9	17.6	18.5	18.8

Calculated on basis of live shrunk weight and chilled carcass weight.
U.S.D.A. carcass grade converted to following numeral 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.
Average of three measurements determined on tracing at the 12th rib.
Marbling scores: 1 to 30, 11 = slight, 14 = small, 17 = modest.
None of the carcass traits were significantly different at the .05 level of probability.

Influence Of Storage Time And Moisture Level On Feeding Value Of Whole Reconstituted Milo For Fattening Cattle

Donald G. Wagner, Ryan Christiansen and Wilburn Holloway

Story in Brief

Five methods of processing milo were compared in high concentrate (90 percent) feedlot rations with finishing heifers to study the influence of storage time and moisture level on the feeding value of whole reconstituted milo. The treatments compared were as follows: (1) dry rolled, (2) reconstituted whole—stored 10 days at 30 percent moisture; (3) reconstituted whole—stored 10 days at 38 percent moisture, (4) reconstituted whole—stored 20 days at 30 percent moisture and (5) reconstituted whole —stored 20 days at 38 percent moisture. Dry milo which was reconstituted in the whole form and stored for 10 days—30 percent H_2O, 10 days—38 percent H_2O, 20 days—30 percent H_2O or 20 days—38 percent H_2O each showed significant ($P<.05$) improvements in feed efficiency of 12.9, 15.6, 15.6, and 15.6 percent, respectively, over dry rolled milo rations. No significant differences ($P<.05$) in feed efficiency existed among the four reconstituted milo treatments.

Introduction

Previous work at Oklahoma and Texas has indicated that reconstitution of milo grain stored in the whole form improves the utilization of milo substantially by fattening cattle. The influence of storage time and moisture level during storage on the feeding value of milo has not been well established. Previous work at Oklahoma has indicated that higher moisture levels, approximately 30 percent or more, and storage times of approximately 20 days or longer produced the greatest improvement in feed utilization. Moisture contents of 30 percent produced significantly greater improvements in feed utilization than reconstitution at moisture levels of 22 percent; however, reconstitution at moisture levels above 30 percent, for example 38 percent, tend to produce only a slight additional response beyond that obtained with 30 percent moisture.

Numerous factors might influence the storage time required, including moisture level, temperature, type of grain and the like. Shorter storage times would be highly advantageous for lowering the cost of reconstitution in that more grain could be cycled through an expensive storage structure in a given time. On the other hand, attempts to reconstitute whole sorghum grain using very high moisture levels presents practical problems in obtaining the desired grain moisture content in a satisfactory period of time. The objective of this experiment, therefore, was to determine if very high moisture levels would be beneficial in reducing the time required to obtain the benefits of reconstitution.

Materials and Methods

Choice Angus heifers, weighing approximately 440 pounds, were selected for use in a 140 day feeding period. The heifers were gradually adapted to a high-concentrate (90 percent) ration during a three week preliminary period. At the beginning of the preliminary period, the heifers were vaccinated for IBR, blackleg-malignant edema, leptospirosis and parainfluenza.

Following the preliminary period, the heifers to be used were divided into two blocks on the basis of weight. A slaughter sample was selected at random from each block to permit net energy values of the experimental rations to be determined by specific gravity using the comparative slaughter technique. The remaining 50 heifers were then allotted within blocks to five treatments, giving five animals per pen and 10 animals per treatment. The milo for each of the treatments was processed as follows:

1. Dry rolled
2. Reconstituted in whole form—stored 10 days at 30 percent moisture
3. Reconstituted in whole form—stored 10 days at 38 percent moisture
4. Reconstituted in whole form—stored 20 days at 30 percent moisture
5. Reconstituted in whole form—stored 20 days at 38 percent moisture

Reconstituted milo containing 30 percent moisture was acquired by mixing dry milo with water and stirring in a cement mixer for approximately 45 minutes. Reconstituted milo containing approximately 38 percent moisture was obtained by steeping or soaking dry milo in water for 12 hours. All reconstituted milo treatments were then stored in air tight plastic bags for the number of days indicated. Prior to feeding, the milo in all treatments was rolled through a 12 x 18 inch roller mill.

The experimental rations consisted of a 90 percent concentrate mix-

ture as indicated in Table 1. The ration ingredients other than milo were combined in a premix and then mixed with the processed milo in a combination of 84 percent milo and 16 percent premix on a 90 percent dry matter basis at the time of feeding. Samples were collected at frequent intervals to permit accurate formulation of ingredients on a 90 percent dry matter basis. The rations were fed one time daily in quantities which would assure availability of feed until the next feeding. Unconsumed feed was weighed back each day to assure a supply of fresh feed at all times.

Stilbestrol was implanted at the 12 mg level at the beginning of the feeding period. Initial and final weights were taken after a 16 hour shrink off feed and water.

Results and Discussion

The proximate analysis and moisture composition data for the processed milo are shown in Table 2. As indicated, the actual moisture con-

Table 1. Ration Composition

Ingredient	Amount[1]
	%
Milo	84.0
Dehydrated alfalfa meal pellets	5.0
Cottonseed hulls	5.0
Soybean meal (44%)	4.2
Urea (45% N)	0.6
Salt	0.4
Dicalcium phosphate	0.4
Calcium carbonate	0.4
	100.0
Add per lb. of ration:	
Vitamin A	1600I.U.
Aureomycin	5 mg.

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

Table 2. Proximate Analysis

Feed	Dry Matter	Crude Protein	Ash	Ether Extract	Carbohydrates
			%		
Milo		10.74[1]	1.20[1]	2.79[1]	85.27[1,2]
Dry rolled	85.3				
10 Days — 30% H_2O	71.1				
10 Days — 38% H_2O	63.4				
20 Days — 30% H_2O	70.7				
20 Days — 38% H_2O	64.2				

[1] Values expressed on a 100% D.M. basis.
[2] 100 — (Sum of figures for crude protein, ash and ether extract).

tents were 28.9, 36.6, 29.3, and 35.8 percent for the 10 Day—30 percent, 10 Day—38 percent, 20 day—30 percent and 20 day—38 percent treatments, respectively, being slightly lower than intended in all cases.

The particle size and density data are presented in Table 3. In all cases, the reconstituted milo treatments were much bulkier than the dry rolled milo, with little difference among the wet treatments.

The feedlot performance data for feed intake, rate of gain and feed efficiency are given in Table 4. No significant differences existed among treatments in rate of gain. The concern is occasionally expressed by cattle feeders that reconstituted feeds are sometimes detrimental to feed intakes and rate of gain. As noted in Table 4, the daily gains on all four wet or reconstituted treatments were at least as high as on the dry rolled milo treatment. Problems associated with poor gains on reconstituted grains as sometimes observed in the field are probably associated with such factors as improper ration formulation, feed spoilage, poor bunk line management and the like. Feed intakes tended, however, to be lower, although not significantly different at the .05 level, on the four wet treat-

Table 3. Particle Size and Density of Processed Milo

Process	Screen Size						Wt.[1] per Bu.
	4.0 mm	2.0 mm	1.0 mm	500 micron	250 micron	250 micron	
		Percent Retained on Screen				Through	lb.
Dry rolled	0	8.4	66.8	12.1	11.8	0.9	48
10 Day — 30% H_2O	36.2	43.5	8.3	5.4	5.8	0.8	33
10 " — 38% "	33.1	46.8	8.7	6.8	4.4	0.2	33
20 " — 30% "	35.1	40.5	9.1	7.0	8.0	0.3	35
20 " — 38% "	16.9	56.6	9.7	10.4	6.4	0.1	35

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

	Dry Rolled	Reconstituted Whole & Stored 10 Days		20 Days	
		30% H_2O	38% H_2O	30% H_2O	38% H_2O
No heifers	10	10	10	10	10
Initial weight, lb.	440	444	438	438	440
Final weight, lb.	773	805	787	800	778
Daily feed, lb.[1]	17.1	16.7	15.6	16.3	15.1
Daily gain, lb.	2.38	2.58	2.50	2.59	2.42
Feed/lb. gain, lb.[2]	7.43[a]	6.47[b]	6.27[c]	6.28[b]	6.28[b]
% Improvement in[3] Feed Efficiency		+12.9	+15.6	+15.6	+15.6

[1] Expressed on a 90% D.M. basis.
[2] Any two averages without a common letter differ significantly ($P<.05$)
[3] Improvement over dry rolled.

Table 5. Slaughter and Carcass Information

	Dry Rolled	Reconstituted Whole & Stored 10 Days		20 Days	
		30%	38%	30%	38%
Dressing %[1,5]	61.8	61.6	61.5	62.0	62.6
Carcass grade[2,5]	9.5	10.0	9.6	9.7	10.3
Ribeye area, sq. in.[5]	10.4	10.8	10.2	10.9	11.0
Fat Thickness, in.[3,5]	0.75	0.74	0.82	0.70	0.69
Marbling[4,5]	12.1	13.6	12.7	13.0	15.2

[1] Calculated on basis of live shrunk weight and chilled carcass weight.
[2] U.S.D.A. carcass grade converted to following numeral 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.
[5] None of the above differences were significant at .05 level of probability.

ments. The lower feed intakes on the reconstituted treatments were reflected in significantly better ($P<.05$) feed efficiencies of 12.9, 15.6, 15.6 and 15.6 percent on the 10 day—30 percent, 10 day—38 percent, 20 day—30 percent and 20 day—38 percent treatments, respectively over dry rolled milo.

No statistically significant differences in feed efficiencies existed, however, among the four reconstituted milo treatments. Net energy values, using the comparative slaughter technique, are also being determined on the above treatments. Furthermore, dry rolled milo and 20 day—38 percent reconstituted milo treatments are being compared using respiration calorimetry. Although no statisticaliy significant differences in feed efficiency existed among the four reconstituted treatments in this experiment, the data in this study together with some additional laboratory and animal performance data might suggest that longer storage times, approximately 20 days or more, may be most beneficial for deriving the maximum benefit from reconstitution of milo at 30 percent moisture, and that increased moisture levels may decrease the time required. From a practical standpoint, however, it would appear questionable if moisture levels much over 30 percent can be justified due to the difficulties associated with achieving moisture contents as high as 38 or 40 percent when reconstituting milo.

Carcass characteristics and dressing percentage were not significantly affected by processing method ($P<.05$).

Association Between Certain Live and Carcass Measurements in Swine

Conall E. Addison, I. T. Omtvedt and L. E. Walters

Story in Brief

Fifty-nine Hampshire market pigs from the swine breeding project were evaluated for carcass merit using ^{40}K count, probe backfat thickness, carcass backfat thickness, loin eye area and yield of lean cuts. Pigs were removed form test on a weekly basis and held off feed and water for 24 hours prior to obtaining ^{40}K content measurements. Each pig was counted for two 5-minute periods prior to slaughter in a detector configuration designed specially for pigs. Immediately following slaughter, the carcasses were mounted on a rack designed to simulate the animal in a standing position to aid in carcass ^{40}K counting. The warm carcasses were counted for two 5-minute periods. Following chilling, the carcasses were divided into closely trimmed hams, loins and shoulders. These very lean cuts provided the end-point for comparing the usefulness of both live and carcass measurements.

Correlations between first and second live ^{40}K counts and first and second carcass ^{40}K counts were determined to estimate the repeatability of the ^{40}K counter. These correlations were 0.90 for live counts and 0.97 for carcass counts. Since this was a uniform group of pigs, these values indicate that the counts were quite highly repeatable.

The correlation between live ^{40}K counts and carcass ^{40}K counts was 0.86 in this study. Carcass ^{40}K count accounted for approximately 70 percent of the variation in lean cut yields while ^{40}K count on the live animal accounted for about 50 percent of the variation. The correlations between ^{40}K count and lean yield were higher when based on carcass weight than when based on live weight. Probed backfat thickness accounted for about 40 percent of the variation in lean cut yields compared to less than 20 percent of the variation accounted for by loin eye area or carcass backfat thickness.

The results obtained indicate that ^{40}K count may be a useful tool in evaluating muscling in live market hogs, but additional work is needed

to study the relationship between live ^{40}K count and a more precise endpoint than the yield of lean cuts used in this study.

Introduction

Increased emphasis placed on muscling in meat animals has created a greater need for more accurate methods for evaluating breeding animals with respect to composition. Livestock breeders have relied on carcass data of relatives to estimate the carcass merit of breeding animals, but this is not as accurate as measuring the amount of lean directly on the animal in question.

Backfat probes and ultrasonic devices are useful aids to selection but they are only estimates of composition since they do not directly measure the amount of lean in an animal. The whole body scintillation counter as an instrument for evaluating the amount of lean in an animal has been introduced recently and results obtained with beef cattle indicate that the method shows promise as a tool for live estimation of composition.

This study was initiated to evaluate the relationships between ^{40}K counts of live pigs and pork carcasses and the yield of lean cuts using a detector configuration designed specially for pigs. A second objective was to compare the ^{40}K method of evaluation with using live or carcass backfat thickness measurements or loin eye area as indicators of muscling.

Materials and Methods

The study included 59 Hampshire pigs farrowed in the fall of 1969 in the swine breeding project herd at Stillwater. All pigs were fed in groups of approximately 60 pigs per pen at the Experimental Swine Barn and weighed off test on a weekly basis as they reached 215 lbs. Three probe backfat measurements (behind the shoulder, at the last rib and in front of the ham) were taken when the pigs were removed from test with the average of the three readings being recorded. After being held off feed for 24 hours, the pigs were evaluated for ^{40}K content at the University Live Animal Evaluation Center. The shrunk live weight for the pigs used in this study was 206.9 lbs. The counter originally designed for evaluating cattle weighing up to 1200 lbs. was modified to accommodate swine by mounting the detector logs in a smaller configuration closer to the body of the animal. Each animal was evaluated using five 1-minute counts. After each pig had been counted once, they were randomly assigned to the counter for a second 5-minute evaluation period. Five 1-minute background counts were taken before and after the animal was confined to the chamber to determine the ^{40}K activity of the empty

chamber. The average of these two background measurements was subtracted from the average of the five 1-minute counts obtained while the pig was in the chamber to obtain net ^{40}K count for each animal.

The pigs were slaughtered the day after being evaluated for ^{40}K content and the carcasses were positioned on a rack designed to simulate the animal in a standing position. The warm carcasses were then returned to the ^{40}K counter and counted twice for five 1-minute periods and corrected for average background counts using the same procedure as was used for the live pigs. The carcasses were then split and processed into closely trimmed hams, loins and shoulders. Loin eye area for the right side was evaluated behind the tenth rib prior to removing the outside fat cover. The means and standard deviations for the traits evaluated are presented in Table 1.

Results and Discussion

One of the prerequisites for any evaluation measurement is that it must be repeatable. In this trial, the correlation between first and second ^{40}K live count on the same animal was 0.90, while the correlation between first and second carcass count was 0.97. Although correlations closer to unity would be desirable, these are considered satisfactory repeatabilities considering the uniform group of pigs evaluated.

The correlation between live animal ^{40}K count and carcass ^{40}K count on the same animal in this study was 0.86. Average ^{40}K counts for both the live animal and the carcass were more closely related to lean cut yield than were probe backfat, carcass backfat or loin eye area (Table 2). Although probe backfat thickness was more closely correlated with yield of lean cuts than was either carcass backfat or loin eye area, it accounted for less than 40 percent of the variation in lean yields compared to about

Table 1. Means and Standard Deviations for Traits Evaluated.

Trait	Mean	Standard Deviation
Shrunk live wt., lb.	206.9	5.5
Carcass weight, lb.	152.6	4.8
Probe backfat thickness, in.	1.29	0.15
Carcass backfat, in.	1.13	0.14
Loin eye area, sq. in.	5.80	0.45
Ham, loin, shoulder wt., lb.	84.1	4.25
Lean cuts of live wt., %	40.7	1.76
Lean cuts of carcass wt., %	55.1	2.37
Net live ^{40}K count	7526	592
Net carcass ^{40}K count	6959	533

Table 2. Correlations Among Various Methods of Evaluation and Yield of Lean Cuts.[1]

	Weight of Lean Cuts	Percent Lean Cuts of:	
		Live wt.	Carcass wt.
Live ^{40}K count	0.75	0.69	0.72
Carcass ^{40}K count	0.84	0.82	0.84
Carcass backfat thickness	—.30	—.36	—.48
Probe backfat thickness	—.56	—.61	—.71
Loin eye area	0.55	0.44	0.33

[1] All correlations significant at $P<.05$.

60 percent accounted for by ^{40}K counts. Carcass ^{40}K counts were more closely associated with lean yield than were live ^{40}K counts. Carcass count accounted for approximately 70 percent of the variation in lean yield compared to only about 50 percent accounted for by live count.

Backfat thickness was more highly correlated with lean cuts of carcass weight than with lean cuts of live weight. Carcass backfat thickness consistently accounted for a smaller amount of the variation in lean yield than did loin eye area, but probe backfat thickness was more closely associated with lean yield than was either carcass backfat thickness or loin eye area. Carcass backfat and loin eye area accounted for less than 20 percent of the variation in lean yields compared to about 40 percent accounted for by using probe backfat thickness.

Although additional work is needed to evaluate the relationship between live ^{40}K count and a more precise end-point than the yield of lean cuts used in this study, the results obtained indicate that it can be a useful tool for evaluating muscling in the live pig.

Effect Of Measuring Tenderness With The Tenderometer

R. L. Henrickson and J. L. Marsden

Story In Brief

Ninety-nine Angus steer carcasses weighing 540 lb. were evaluated for tenderness of the longissimus dorsi muscle. Breeding, feeding, and environmental treatments of the animals were similar. All animals were slaughtered 24 hours after their arrival at the plant. The carcasses were ribbed after a 24 hour chill at zero degrees centigrade and tenderometer measurements were made on the longissimus dorsi of the wholesale rib. The influence of muscle temperature, repeated penetration, quality of fat, iodine number, fiber diameter, degree of fiber kinkiness and Warner-Bratzler shear values were evaluated.

Introduction

Tenderness is one of the most favored attributes of meat. Most of the common European cattle breeds have been selected so that fed cattle generally provide tender meat. However, in recent years, greater emphasis has been placed on cross breeding to improve various attributes of production. This change in breeding practice may introduce considerable variation in meat tenderness. The need and desire to monitor meat tenderness, in the live animal, and the carcass, has increased.

Attempts to relate objective tenderness measures of raw meat with cooked meat tenderness failed to show any significant correlation, Warner (1928), Black (1931), Mjoseth (1962), Carpenter, et al. (1965). Measured tenderness values for raw meat by the wedge tenderometer, denture tenderometer, and grinder tenderometer were reported by Carpenter, et al. (1965). They found the association with a taste panel to be small.

Various types of penetrometers have been used to measure texture, firmness, and tenderness. Pilkington, (1964) used several shaped penetrometer points to measure firmness. However, firmness did not relate highly with tenderness. Bourne, et al. (1966) reported, that the puncture force for different punches on the same food will be a function of both area and perimeter of the punch used. A problem of great concern when using the penetrometer on raw meat has been to obtain a good relationship of this measure with tenderness of cooked meat. Hinnergardt and Tuomy (1970) reported on a study which evaluated the use of a single

penetration test of raw meat to predict the tenderness of cooked meat. They found that the maximum force value gave the best results.

The purpose of this work was to evaluate the Armour "tenderometer" a simple, rapid, non-destructive carcass measure of tenderness.

Procedure

The battery operated tenderometer consists of a probe assembly and a readout unit. The probe assembly includes 10 penetration needles, each 3 inches long, mounted on a manifold which is in turn attached, by cable, to an electronic strain gauge. The ten, pointed needles, made of stainless steel are mounted so as to penetrate the muscle a maximum distance of two inches. The instrument was designed to be used on the longissimus dorsi muscle at the areas of the 12th and 13th thoracic vertebrae. Readings are to be taken on muscle chilled to less than 39.20° F (4°C) and not more than 32° F (0°C). Consequently, a measurement should not be taken until at least 24 hours after slaughter.

Ninety-nine head of angus steer carcasses weighing 540 pounds were evaluated for tenderness of the longissimus dorsi muscle. Breeding, feeding, and environmental treatments of the animals were similar so as to reduce the tenderness variables. All animals were trucked 140 miles from the station feedlot to the abattoir. Feed and water were provided during the 24 hour rest period prior to slaughter. Fifty head were slaughtered 24 hours after arrival at the plant and 49 head slaughtered after 48 hours.

The carcasses were ribbed 24 hour after slaughter, between the 12th and 13th thoracic vertebrae, and a federal employee evaluated each carcass for amount of marbling and grade. Immediately after grading, tenderometer readings were made on the longissimus dorsi muscle. The internal muscle temperature was recorded using a thermometer inserted into the muscle. One-half of each carcass was divided into wholesale cuts and the wholesale rib returned to the research laboratory for further analysis. Upon arrival at the laboratory, a tenderometer measurement of each longissimus dorsi muscle, its temperature, and area tracing, were again recorded. When the temperature of the longissimus dorsi muscle had equalized to 36°F (12 hr. at 36°F), another tenderometer measurement of the longissimus dorsi muscle was made. Care was taken in the replacement of the needle to avoid previously penetrated areas of the muscle.

A two-inch slice of the penetrated longissimus dorsi muscle was removed from each wholesale rib to be used for the Warner-Bratzler shear test. An adjacent one-inch slice was removed from the longissimus dorsi muscle so as to provide tissue for histological observations and ether extract measurements.

Table 1. Mean, Standard Deviation and Range for Carcass and Tissue Variable of Tested Animals.

	Mean	S. Dev.	Range
Carcass wt. lb.	541.0	57.6	405-666
L. Dorsi area sq. in.	10.2	1.1	8.1-12.9
Fiber Diameter u.	64.2	6.4	75.4-81.4
Carcass grade score[1]	10.4	1.2	8.0-13.0
Marbling score[2]	5.2	1.1	3.0-8.0
Ether Extract %	5.8	1.9	2.3-11.3

[1] Carcass score ranged from 8 (average good) to 14 (top prime).
[2] Marbling score ranged from 3 (traces) to 9 (abundant).

Three one-half inch diameter cores were removed from the dorsal, central, and ventral areas of the one-inch thick muscle sample and placed in 10 percent formalin. The remainder of the muscle was made into a composite paste and analyzed for its fat content.

The formalin fixed tissue provided fibers to be evaluated for their degree of rigor mortis. To harvest the fibers, a single fascicula was placed in a mechanical mixer and stirred at a slow speed. When the fibers were dislodged, they were placed in a petri dish to be evaluated for degree of rigor and diameter measurement at 100x.

Results and Discussion

Animals used in the investigation were generally homogeneous in so far as production factors were concerned. Carcass weight ranged from 406 to 666 pounds with a mean of 541 pounds. The carcasses were generally muscular as reflected by the mean L. dorsi area of 10.2± 1.1 sq. in. with a range of 8.1 to 12.9 sq. in. The fat content of the L. dorsi muscle, as evidenced by the ether extract value, was 5.8± 1.9 percent (range 2.3 to 11.3 percent). The designated average federal grade was choice with the numerical score being 10.4± 1.2. A highly significant difference due to animal variation and tenderometer reading was noted (Table 2).

The multi-point penetrometer was easy to use in the cooler while working a rail of carcasses. A measurement can be rapidly made without

Table 2. Analysis of Variance

Source	dF	MS	F
Animal	98	15.506	5.79
Tenderometer	3	263.364	98.39
Error	294	2.677	
Total	395		

damage to the carcass or description of the daily normal cooler operation. The in-plant tendrometer reading, made on the rib L. dorsi muscle was greater than any of the three measurements made on the wholesale rib after it was returned to the laboratory (Table 3). Penetration force variance may be attributed to the difference in product temperature and/or the degree of fiber rigor. Since the same muscle area was penetrated a second time, this too may have affected the reading. No repeatability measurements were made to varify this potential variable. When the muscle temperature and cooler temperature (36°F) were permitted to equilibrate, (48 hr.) tenderometer readings were not different from those recorded at 30 hr. post-mortem (Table 3). Fat firmness and quantity would likely have an effect on the tenderometer reading. Firm fat would require more force to insert the needles. The fat in turn would be beneficial as the muscle was heated. Thus, the tenderometer reading would be inversely related to the quantity of fat located within the muscle.

The kind of fat as reflected by the iodine number, within the L. dorsi muscle was not found to vary in these carcasses regardless of fat quantity (Table 4). Muscle with 3.4 percent fat possessed an iodine number of 44.5, while muscle with 9.2 percent fat was 43.3.

Fiber size and compactness was considered a factor which would likely influence the penetration force. Fiber diameter in this group of bovine muscles ranged from 75.5 to 81.4 microns. It was assumed that this 6 micron difference would not greatly influence the tenderometer reading (Table 1).

Fiber rigor is a factor which could be a very influential factor. The quantity of rigor fibers ranged from 14 to 83.4 percent (Table 3). This measurement was made on the tissue 48 hours after death. This time period elapse would likely be sufficient for some resolution to take place. Therefore, tenderometer readings taken 24 hours after death would like-

Table 3. Mean Shear Force, Degree Rigor Fibers and Tenderometer Values for Bovine L. Dorsi Muscle.

		Mean	S. Dev.	Range
Shear Force	lb.	18.29	4.3	9.9-18.3
Degree Rigor	%	36.37	15.3	14.0-83.4
Tenderometer	A lb.	17.10	2.6	12.0-23.4
	B lb.	14.72	2.5	9.0-20.0
	C lb.	14.96	2.3	9.7-20.5
	D lb.	13.12	2.2	8.4-18.4

A. Muscle temperature 37.3°F, 24 hours post-mortem, in plant measurement.
B. Muscle 42°F, 30 hours post-mortem, in lab measurement.
C. Muscle 36°F, 48 hours post-mortem, in lab measurement.
D. A two inch slice was removed and penetration was made into the new muscle surface, 36°F, 48 hours post-mortem.

Table 4. Iodine Values of Fat from the Bovine L. Dorsi Muscle

Fat %	Range	Iodine Value
3.4	3.1- 3.8	44.5
9.2	8.2-11.3	43.5

[1] Twelve muscle samples were used at each fat level. Each measure was made in duplicate.

ly be greater and more varied than a similar reading registered after 30 to 48 hours.

Connective tissue within the muscle would also be a factor influencing the tenderometer reading. Not only would the amount of connective tissue be an important variable, but its composition would also be influential. Connective tissue with large quantities of elastin would likely provide more resistance to penetration than tissue composed only of the protein collagen. This variable was not evaluated but will be considered as the work is continued.

Correlation coefficients indicated that the Warner-Bratzler shear force machine and the tenderometer were not related (Table 5). Both units measure an element of tenderness. However, in the case of the tenderometer one measures the force necessary to separate the individual raw muscle fibers. While the Warner-Bratzler shear measures the force required to cut the cooked fibers at right angle to their long axis. The degree of fiber rigor, fiber diameter, fat level, or muscle area were not significantly correlated with the tenderometer force.

Summary

The Armour Tenderometer is easy to use in the cooler. Readings may be taken using the L. Dorsi muscle 24 hours after slaughter. Force required to insert the manifold of needles varied greatly within a homogenous group of carcasses, reflecting that some tissue difference does exist. Tenderometer measurements made in the plant using the carcass were larger than those made in the laboratory using the wholesale rib. Force required to insert the penetrometer into the L. dorsi muscle 48 hours after death, was significantly less than at 24 or 30 hours. Even though the degree of rigor was not shown to be a major factor in the use of this instrument, it may well be an important attribute and should receive further investigation.

The quantity of fat as reflected by marbling and ether extract influenced the tenderometer reading. Fat firmness as reflected by iodine number was not a factor in this group of carcasses. In general, correlations between the Warner-Bratzler shear machine and the tenderometer were low.

Table 5. Correlations Among Factors Which Tend to Influence the Tenderometer[1]

		Marbling	E. Extract	L.D. Area	Fiber Diam.	Deg. Rigor	Tenderometer A	B	C	D	Shear
Marbling		1.00	0.32	—0.21	—0.04	0.14	0.23	0.24	0.37	0.44	—0.29
Ether Extract		0.32	1.00	—0.21	0.01	0.04	0.05	0.12	0.12	0.12	—0.31
L. Dorsi area		—0.21	—0.21	1.00	0.08	—0.28	—0.38	—0.34	—0.33	—0.39	0.08
Fiber diameter		—0.04	0.01	0.08	1.00	—0.03	—0.12	—0.23	—0.06	—0.07	0.04
Degree Rigor		0.14	0.04	—0.28	—0.03	1.00	—0.07	—0.02	0.04	0.05	0.22
Tendermeter	A	0.23	0.05	—0.38	—0.12	—0.07	1.00	0.65	0.56	0.57	—0.15
	B	0.23	0.12	—0.34	—0.23	—0.02	0.65	1.00	0.58	0.43	—0.14
	B	0.24	0.12	—0.34	—0.23	0.04	0.56	0.58	1.00	0.48	0.02
	D	0.44	0.12	—0.37	—0.06	0.05	0.57	0.43	0.48	1.00	—0.01
Shear Force		—0.29	—0.30	—0.08	0.34	0.22	—0.15	—0.14	0.02	—0.01	1.00

[1] Animals used (99) were thirteen months of age and of uniform breeding.

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Relationships Between Sow Condition and Productivity and Effectiveness of Controlling Condition by Individual Feeding

I. T. Omtvedt and Mike Moss

Story in Brief

The farrowing and weaning records for 141 litters were used to evaluate the relationship between sow condition score and differences in productivity. Each sow was scored for condition using a 9 point scale at breeding, farrowing and weaning and these scores were correlated with litter size and pig weights. Neither breeding scores or farrowing scores accounted for a significant portion of the variation in sow productivity, but gilts with higher condition scores at farrowing and those showing greatest increases in condition during gestation tended to farrow smaller litters. Condition scores at weaning and changes in condition score during lactation were correlated with litter production in that loss of condition during lactation and lower condition scores at weaning were associated with larger, heavier litters.

The variation in condition scores at farrowing among sows limited fed using troughs during gestation was compared to the variability among sows limited fed during gestation using individual sow feeding stalls. The variation in scores among the 95 sows fed in troughs was about twice as large as the variation obtained among the 246 sows fed in feeding stalls.

Introduction

Feeding for optimum production in sows requires controlled feed intake during various stages of production. Research has shown that flushing sows a couple of weeks prior to breeding by increasing feed intake tends to increase ovulation rate while restricting consumption immediate-

In cooperation with the Agriculture Research Service, Animal Science Research Division, USDA.

ly following breeding and during gestation reduces embryo mortality. Optimum productivity depends on keeping sows in proper condition at all stages of the reproductive cycle.

When sows are limited fed in groups, some sows usually receive more than their share of feed and are essentially overfed while the more timid, slower eating sows are crowded out. The use of individual sow feeding stalls permits one to more closely regulate the feed intake for each sow but the problem of determining what constitutes optimum condition still remains. To further elucidate this problem, a visual condition scoring system was used in the swine breeding herds starting in 1965.

The objectives of the present study were to evaluate the relationships between differences in sow condition score with differences in productivity, and to determine the effectiveness of employing individual feeding stalls in reducing the amount of variation in condition among sows in the herd.

Experimental Procedure

A 9 point scoring system was used in this study to measure sow condition at the time of breeding, farrowing and weaning. Scores of 1, 2 or 3 indicated thin, under-conditioned sows, 4, 5 or 6 denoted sows in the desired moderate condition, and 7, 8 or 9 signified for those carrying too much finish.

Initially all sows were scored both by the project leader and the herdsman for the herd involved, but since the variation between scorers was relatively small only the herdsman for each herd awarded scores after the first season.

To determine the relationships between condition score and productivity, 141 sows farrowing during 1965 fall and 1966 spring were used. The distribution of litters by line of breeding and age of dam are given in Table 1. These sows were flushed prior to breeding and limit fed in groups during gestation, but no attempt was made to regulate individual feed intake during these seasons. Condition scores were given each sow

Table 1. Distribution of Litters by Line of Breeding and Age of Dam for Determining Correlations Between Condition Scores and Productivity.

Age of Dam	Line of Breeding				
	Duroc	Belts. #1	Hamp.	Crossbred	Total
Sows	20	26	21	25	92
Gilts	--	--	18	31	49

at breeding, farrowing and weaning with litter production evaluated at farrowing and weaning.

To evaluate the reduction in variability of condition among sows resulting from individual feeding, data for 6 farrowing seasons including 341 litters were used. The distribution of litters by season, age of dam and line of breeding are given in Table 2.

Results and Discussion

Phenotypic correlations were calculated to evaluate the relationships between condition scores and productivity for gilts and sows separately and then pooled overall. The results obtained are summarized in Table 3.

Breeding Score and Weight. Although neither condition score or weight at breeding were closely associated with productivity, there was a tendency for gilts with higher scores at breeding to farrow fewer pigs.

Farrowing Score and Weight. Gilts with higher condition scores at 109 days postbreeding farrowed fewer pigs. This same relationship was noted among sows but the correlation was not significant. Overall, the heavier sows and gilts at farrowing time produced pigs with heavier birth weights.

Score Change and Weight Change During Gestation. The change in scores and weights from breeding to farrowing accounted for very little of the variation in productivity. Although most correlations obtained were not significant, an increase in condition during gestation in gilts tended to be associated with decreased productivity. The correlations involving sow weight gains were generally of a positive nature.

Weaning Scores and Weights. Scores and weights obtained at weaning were more closely associated with productivity than those taken at either breeding or farrowing. In general, sows with lower scores and

Table 2. Distribution of Litters by Breed, Age of Dam and Season Used to Study Varability in Condition Scores.

Season	Feeding System	Hampshire		Crossbred	
		Gilts	Sows	Gilts	Sows
1965 Fall	Group Fed	18	7	10	16
1966 Spring	System[1]	12	14	21	9
1966 Fall	Individual Stalls	25	5	17	10
1967 Spring	Individual Stalls	21	13	19	11
1967 Fall	Individual Stalls	17	14	12	11
1968 Spring	Individual Stalls	19	9	21	10
		112	62	100	67

[1] Hampshire gilts fed in individual stalls; others group fed.

Table 3. Phenotypic Correlations Pooled over Breed, Year and Season for Gilts and Sows.

Traits	Gilts	Sows	Overall
Number of Litter Records	49	92	141
Breeding Score and:			
Number farrowed alive	—.17	—.07	—.09
Pig birth weight	—.04	0.13	0.09
Litter birth weight	—.18	0.01	—.04
Breeding weight and:			
Number farrowed alive	0.16	0.05	0.07
Pig birth weight	0.13	0.14	0.13
Litter birth weight	0.24	0.13	0.16
Sow 109-day score and:			
Number farrowed alive	—.36*	—.11	0.18*
Pig birth weight	0.0	0.14	0.07
Litter birth weight	—.34*	—.06	—.13
Sow 109-day weight and:			
Number farrowed alive	0.11	0.10	0.15
Pig birth weight	0.26	0.20	0.21**
Litter birth weight	0.26	0.23*	0.24**
Gestation score change and:			
Number farrowed alive	—.25	—.04	—.10
Pig birth weight	—.15	—.01	—.05
Litter birth weight	—.29*	—.09	—.16
Gestation weight change and:			
Number farrowed alive	—.01	0.16	0.13
Pig birth weight	0.27	0.11	0.14
Litter birth weight	0.13	0.26*	0.22*
Sow weaning score and:			
Number raised to 42 days	—.64**	—.39**	—.47**
Average pig weaning weight	0.31*	0.19	0.23**
Litter weaning weight	—.52**	—.36**	—.41**
Survival percentage	—.50**	—.31**	—.25**
Sow weaning weight and:			
Number raised to 42 days	—.44**	—.38**	—.39**
Average pig weaning weight	—.38**	0.30**	0.32**
Litter weaning weight	—.27	—.29**	—.28**
Survival percentage	—.40**	—.13	—.22**
Sow Lactation score change and:			
Number raised to 42 days	—.44**	—.48**	—.46**
Average pig weaning weight	—.05	0.16	0.09
Litter weaning weight	—.35*	—.45**	—.41**
Survival percentage	—.49**	—.30**	—.37**
Sow Lactation weight change and:			
Number raised to 42 days	—.47**	—.52**	—.50**
Average pig weaning weight	0.15	0.22*	0.20*
Litter weaning weight	—.41**	—.46**	—.44**
Survival percentage	—.51**	—.20	—.32**

* Corelation significant at 5% level.
** Correlation significant at 1% level.

lighter weights at weaning raised larger litters and had higher pig survival rates.

Changes in Scores and Weights During Lactation: Increases in weight and condition during lactation was associated with lower productivity. These results indicate that condition score is related to productivity to about the same degree as is sow weight.

Controlling Sow Condition by Individual Feeding Stalls: As indicated in Table 2, prior to 1966 sows in the swine breeding herds were hand fed in groups of less than 20 by using long troughs. Individual feeding stalls were available for the OK14 Hampshire gilts in 1966 spring and from 1966 fall all sows were fed in stalls. To determine if the variation in condition scores was reduced by using individual stalls, the coefficients of variation were calculated for each season in an effort to have some basis for comparing the amount of variation. As can be seen in Table 4, the use of individual feeding stalls apparently was effective in reducing the variation in condition scores among sows since the coefficients of variation were only about half as large after individual stalls were employed.

Table 4. Coefficients of Variation Percentages for Sow Condition Scores at Farrowing by Season, Line of Breeding and Age of Dam.

Season	Hampshire		Crossbred	
	Gilts	Sows	Gilts	Sows
1965 Fall	25.6	28.8	22.5	25.1
1966 Spring	16.4	26.0	29.5	22.3
1966 Fall	13.4	20.0	12.5	14.8
1967 Spring	10.8	12.6	15.9	11.8
1967 Fall	9.2	15.6	15.6	11.9
1968 Spring	12.8	12.3	11.6	14.5

Performance Differences Among Littermate Boars, Barrows and Gilts

I. T. Omtvedt and E. F. Jesse

Story in Brief

The pigs used in this study were selected from each litter prior to weaning on the basis of similar 3-week weights with one male pig from each litter chosen at random to be castrated.

Growth rate data from 184 littermate boar-barrow-gilt trios and carcass data from 237 barrow-gilt littermate pairs were analyzed to evaluate the influence of sex on post-weaning performance and carcass traits. The relative magnitude of these sex differences for different sire groups was also evaluated to investigate the possibility of sire-sex interactions.

Barrows gained faster than boars and gilts, and reached market weight in fewer days than gilts while there was essentially no difference in age at 200 lbs. between boars and barrows. Little difference was noted between barrows and gilts for feed required per unit of gain while boars were considerably more efficient. Boars probed less backfat than gilts and gilts less than barrows. Gilt carcasses were longer, had less carcass backfat and larger loin eye areas than barrows. Trimmed hams, loins and shoulders from gilt carcasses weighed more than lean cuts from barrow carcasses and yielded a greater percentage of lean cuts based on slaughter weight and cold carcass weight. Barrow carcasses were scored higher for firmness and tended to have more marbling in the loin eye but a sire-sex interaction was obtained for marbling score. This would indicate that if marbling is to be evaluated in a testing program, both sexes may need to be included in the test to adequately evaluate a sire's potential for transmitting this aspect of carcass quality to his offspring. Sire-sex interactions were not found in the other traits studied. The correlations obtained showed similar relationships among the various traits when based on either gilt data or barrow data.

Introduction

Sex differences exist for many traits in swine. Since both males and females are oftentimes included in performance testing programs, this necessitates a thorough understanding of the influence of sex on the traits evaluated in order to properly interpret the results obtained.

In cooperation with the Agriculture Research Service, Animal Science Research Division, USDA.

In general, barrows gain faster and reach market weight at an earlier age than gilts, but gilts yield more heavily muscled carcasses with less backfat. Research investigations comparing the performance of boars to the performance of barrows or gilts are very limited and the results that are available are usually biased due to the fact that the boars used represent a highly selected group. Meaningful sex adjustment factors require not only knowledge pertaining to the relative magnitude of these sex differences, but also some assurance that these differences are similar for the various sire groups evaluated.

This study was initiated to evaluate the differences in performance of littermate boars, barrows and gilts selected on the basis of comparable weights at 3 weeks of age and to investigate the similarity of these differences for different sire progeny groups.

Experimental Procedure

Data from the swine breeding research herds at Stillwater and Fort Reno were used in this investigation which extended over a three year period (1965-1967). Performance records on 184 boar-barrow-gilt littermate trios and carcass data on 237 barrow-gilt littermate pairs from five breeding groups were utilized as shown in Table 1. Traits evaluated included growth rate, feed efficiency, backfat thickness, carcass length, loin eye area, lean-cut yield, marbling and firmness.

The pigs used in these analyses were selected prior to weaning on the basis of similar weights at 21 days. The 184 littermate boar-barrow-gilt pairs were used in the carcass evaluation. In selection of trios, two males and one female were chosen from each litter and then one of the male pigs was selected at random to be castrated prior to weaning. The littermate pairs used in the carcass evaluation included the barrow and gilt from the trio when available plus additional barrow-gilt littermate pairs selected on the basis of similar 21-day weights.

Pigs were self fed milo-wheat-soybean meal rations containing 16 percent protein from weaning to 120 lb. and 15 percent protein from 120

Table 1. Distribution of Littermate Pairs and Trios by Line of Breeding.

Line of breeding	No. Pairs	No. Trios
Duroc	--	16
Beltsville No. 1	49	21
Hampshire	79	47
2-line cross (Belts x Duroc)	42	59
3-line cross (Hamp x Belts-Duroc)	67	41
Total	237	184

lb. to 200 lb. Pigs were fed in confinement in groups of 6 pigs per pen from 8 weeks of age until end of test. Feed records were obtained on a pen basis for 6 pigs of the same sex.

Pigs were removed from test and probed on a weekly basis as they weighed 200 lb. The probe backfat measurements were taken approximately 1.5 in. off each side of the mid-doral line behind the shoulder, at the last rib and the last lumbar vertebrae.

Carcass weights and measurements were taken 48-hours after slaughter. Area of *l. dorsi* muscle and quality scores were obtained from the right side of the carcass at a cross section of the loin between the 10th and 11th ribs. The loins were scored for firmness and marbling by a committee of three evaluators and the average of their scores was used in the analysis. The weights of the closely trimmed loins, hams and shoulders from both sides of the carcass were obtained and expressed as a percentage of off-test weight and as a percentage of cold-carcass weight. Samples for ether extract and total moisture determinations were taken from the *l. dorsi* muscle at the 9th and 10th rib section. Since not all lines of breeding appeared each season, analyses were done within season and line and pooled over season and line under the assumption of equal variances.

Results and Discussion

Data for the performance traits of 184 boar-barrow-gilt full-sib trios and for the carcass traits of 237 barrow-gilt parts are summarized in Table 2.

Even though the pigs from each sex within a litter were selected to be of approximately equal weight at three weeks of age, the difference in weight at weaning between sexes was significant ($P<.01$). A difference in weight between boars and barrows at weaning was expected since the male selected to be the barrow was castrated at approximately five weeks and the weaning weights possibly still reflect the stress imposed on the barrows by castration.

Barrows gained 0.20 lb. per day faster and reached market weight approximately 10 days sooner than gilts. The barrows averaged 0.05 lb. per day faster gain than the boars, but because of weaning weight differences, there was essentially no difference in the time required to reach market weight. Differences in weaning may have influenced the differences observed in postweaning daily gain since weaning weight and postweaning gain are positively correlated. Since the boars were heavier at weaning than the barrows, the differences observed in average daily gain during the postweaning phase were possibly not as large as would have been obtained if the two groups had been equal in weight at weaning.

Table 2. Means and Standard Deviations for Performance and Carcass Data of Littermate and Trios and Littermate Pairs.

	Boars	Barrows	Gilts	Standard Deviation
Numbers of littermates	184	184	184	
42-day wt., lb. **	29.3	28.3	28.8	1.80
Postweaning daily gain, lb.**	1.75	1.80	1.60	.15
Days to 200 lbs.**	148	147	157	3.7
Feed per unit gain, lb.**	2.60	2.87	2.89	.10
Probe backfat at 200 lb., in.**	1.18	1.36	1.24	.11
Carcass data:				
Number of littermates		237	237	
Cold carcass weight, lb.		144.9	144.3	3.83
Carcass length, in.**		29.6	30.1	.54
Backfat thickness, in.**		1.36	1.26	.11
Loin eye area, sq. in.**		4.20	4.67	.37
Total wt. of ham, loin and shoulder, lb.		77.3	80.2	2.88
Lean cuts of off-test wt., %**		38.7	40.5	1.25
Lean cuts of carcass wt., %**		53.4	55.6	1.61
Marbling score[1]*		3.7	3.3	.99
Firmness score[1]**		4.4	3.9	1.13
Ether extract, %**		4.8	3.9	1.56
Total moisture, %**		70.8	71.2	1.49

[1] Loin eye muscle at 10th rib was scored for marbling and firmness. Scores ranged from 1 to 7 with 1 = devoid of marbling and very soft and 7 = abundant marbling and very firm.
*Sire-sex interaction significant ($P<.05$).
**Difference between sexes significant ($P<.01$).

Boars required 27 lb. and 29 lb. less feed per cwt. gain than the barrows and gilts, respectively ($P<.01$). The difference between the barrows and gilts was not significant. Other work has shown boars to be more efficient than either barrows or gilts, but considerable variation regarding differences between barrows and gilts have been reported. Although the number of comparisons available are limited, the trend in most other studies has been for gilts to require less feed per unit of gain than barrows.

Gilts probed 0.12 in. less backfat than their littermate barrows in this study while boars probed 0.06 in. less than gilts and 0.18 in. less than barrows. Similar differences in carcass backfat between barrows and gilts were also noted. Gilt carcasses were 0.5 in. longer, had 0.47 sq. in. larger loin eye areas and yielded 2.2 percent more lean cuts of carcass weight than barrows.

The loin eyes of barrow carcasses were scored 0.5 of a unit higher for frimness ($P<.01$) and 0.4 of a unit higher for marbling than the loin eyes of gilt carcasses. However, a sire-sex interaction was obtained for marbling score in that in two lines of breeding (Hampshire and 3-line

cross), the gilts were scored higher than barrows for the progeny of a few sires while barrows were scored higher than gilts for most sire groups.

The presence of the sire-sex interaction for marbling score would indicate that both sexes may need to be included in a progeny testing program to adequately evaluate this aspect of carcass quality. Since sire-sex interactions were not found for any of the other traits, it appears that one can test either sex and apply adjustment factors in a progeny testing program. Although the magnitude of these sex differences may be similar for different sire groups, it should be realized that these sex differences are not constants and that the most accurate progeny test would include animals of all the same sex or include both sexes in equal numbers.

The phenotypic relationships among the various traits for each sex are presented in Table 3. To quantitize the similarity between correlations obtained using barrow data with those obtained using gilt data, a correlation coefficient was calculated between the corresponding correlations for each sex. This correlation between the sets of estimates presented in Table 3 for the 2 sexes was 0.94 indicating that the relationships among the various traits were similar for both sexes.

The correlations presented in Table 3 indicate that an increase in carcass backfat was associated with a decrease in carcass length and per-

Table 3. Phenotypic Correlations for Barrows (Upper Line) and Gilts (Lower Line) Among Carcass Traits Evaluated.

Trait	Sex	Carcass length	Loin eye area	Percent lean of carcass	Marbling score	Firmness score	Ether extract	Total moisture
Carcass backfat	B	—.16*	—.04	—.47**	—.05	0.00	—.03	—.09
	G	—.46**	—.11	—.52**	—.02	0.16*	—.02	—.02
Carcass length	B		—.06	0.18*	0.00	—.08	0.03	0.03
	G		—.13	0.22**	0.10	0.05	0.12	—.07
Loin eye area	B			0.41**	—.17*	—.28**	—.23**	0.15
	G			0.45**	—.13	—.27**	—.16*	0.09
% lean of carcass	B				—.10	—.29**	—.05	0.00
	G				—.10	—.29**	—.05	0.00
Marbling score	B					—.42**	0.48**	—.55**
	G					—.53**	0.62**	—.44**
Firmness score	B						0.39**	—.29**
	G						0.27**	—.19**
Ether extract	B							—.82**
	G							—.79**

* Significant at 5% level.
** Significant at 1% level.

cent lean of carcass while an increase in carcass length was associated with an increase in percent lean of carcass. Increased marbling and fat content were associated with a decrease in loin eye area and total moisture and an increase in firmness. No appreciable relationships were found between fat content and percent lean of carcass.

The Effects of Heat Stress on Rectal Temperatures and Respiration Rates in Gilts

Roger Bates, R. A. Battaglia and I. T. Omtvedt

In the spring of 1970, 24 Hampshire gilts averaging 7 months of age and averaging 208.9 pounds were confined to a cool or hot chamber for a one-week period (2 gilts/chamber/week) to determine the effects of heat stress on rectal temperatures and respiration rate. Both environmental control chambers were also evaluated for capabilities and limitations. When gilts were first subjected to the chambers, both chambers were operated at 70°F. with 60 percent humidity and 5 m.p.h wind velocity. Twenty hours after each group of pigs was confined to the chambers, the temperature in one chamber was elevated to 80°F. and then four hours later elevated to 85°F. and held at that level for the remainder of the confinement period.

The desired chamber temperatures and humidity in the hot chamber were obtained. However, humidity in the cool (70°F.) chamber was affected by increased air moisture content outside the chamber.

Exposure to the chambers tended to induce estrus. Ten gilts (4 in cool chamber and 6 in hot chamber) showed signs of estrus on either days 3 or 4 of confinement. The average rectal temperature for pigs in the cool chamber was 102.4°F. compared to 103.0°F. for those in the hot chamber. As chamber temperature increased rectal temperatures and respiration rates increased. The pigs exposed to the hot chamber had higher average rectal temperatures than the cool chamber pigs at all

periods except at 10:30 a.m. on day 5. Some adaptation to heat stress was apparent on the 4th or 5th exposure day. The daytime average respiration rates for those exposed to heat stress tended to decrease with length of exposure. However, the average daytime high rectal temperature for gilts in the hot chamber was higher ($P<.01$) in the cool chamber on day 2, 3, 4 and 5 of confinement. Both groups exhibited lower average rectal temperatures at 6:30 a.m. each day accompanied by an elevation after feeding.

Based on these results it may be desirable to increase wind velocity above 5 m.p.h. or to install a larger dehumidification system when low chamber temperatures are desired. This study indicates that pigs exhibit a diurnal rectal temperature rhythm in an environment where temperature, humidity, wind velocity and lighting are held relatively constant and that animals tend to show some adaptation to heat approximately 48 to 72 hours after initial exposure.

Introduction

With an increase in confinement rearing of swine, the effects of heat stress on the physiological well-being and performance of swine is of increased concern to the swine producer. Most of the heat stress research has been conducted with facilities that are capable of controlling only temperature. Due to lack of adequate environmental control facilities there is limited data on the effects of constant temperature, humidity and wind velocity on swine.

Many reports indicate that swine will exhibit an increase in rectal temperature and respiration rate upon initial exposure to high temperature. Work done by Edwards *et al.* (1968) at Fort Reno suggests that gilts appear to adapt to high temperatures after about 6 days exposure.

This study was undertaken to investigate the effects of a constant elevated temperature on the rectal temperature and respiration rate in pigs. Since this was the first study involving the new environmental control chambers at the University Science Building, an additional objective was to evaluate the capabilities and practical limitations of these facilities.

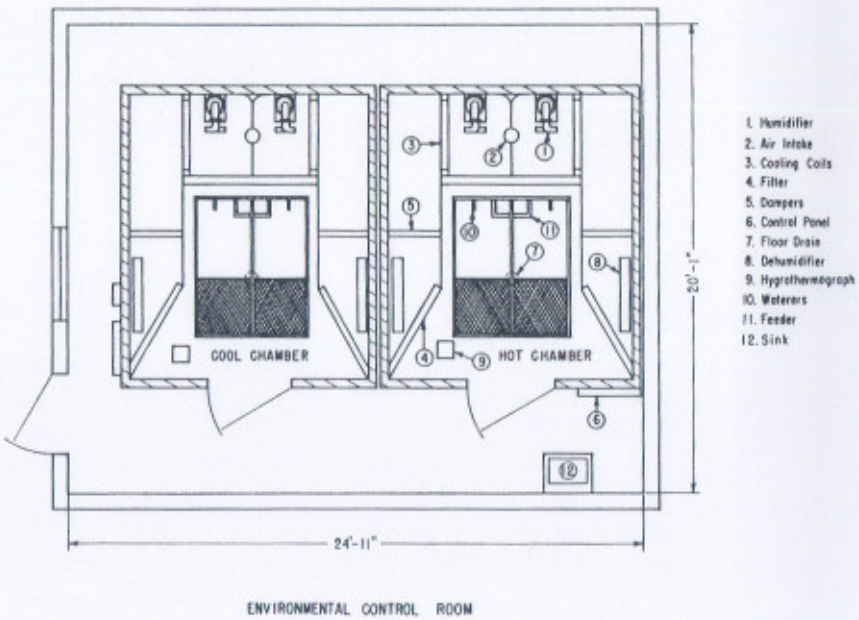
Materials and Methods

This study utilized 24 Hampshire gilts with an average age of 7 months and weighing 208.9±2.9 pounds confined for a one-week period (2 gilts/chamber/week) to either a cool or hot environmental control chamber. These chambers were constructed inside a closed room at the

Veterinary Science Building. Each chamber was equipped with a restraining crate designed to accommodate two 200 pound pigs. These chambers were designed and constructed by Lab-Line Environeers, Division of Lab-Line Instruments, Inc., Melrose Park, Illinois.

One chamber served as a control chamber and was maintained at approximately 70°F., 60 percent relative humidity and 5 m.p.h. wind velocity continuously. The other chamber was operated at 70°F. for 24 hours after initial gilt exposure and was then elevated to 80°F. and then four hours later increased to 85°F. and held at that level for the remainder of each week of confinement. Chamber lighting was continuous for the entire period of gilt confinement. The chambers and restraining crate designs and dimensions are presented in Figures 1, 2 and 3, respectively.

Each gilt was fed 4 pounds of a growing ration at 6:30 a.m. each day and water was supplied *ad libitum*. Rectal temperatures were determined with a large animal rectal thermometer after a 3 minute insertion period. Respiration rates per minute were obtained by counting flank movements. Rectal temperatures and respiration rates were taken at 6:30 p.m. and 10:30 p.m. on day 1, at 6:30 a.m., 10:30 a.m., 2:30 p.m., 6:30 p.m and 10:30 pm on day 2, 3, 4 and 5, and at 6:30 am. and 10:30 a.m. on



ENVIRONMENTAL CONTROL ROOM

Figure 1. Environmental control room showing location of environmental chambers, restraining crate position and work area.

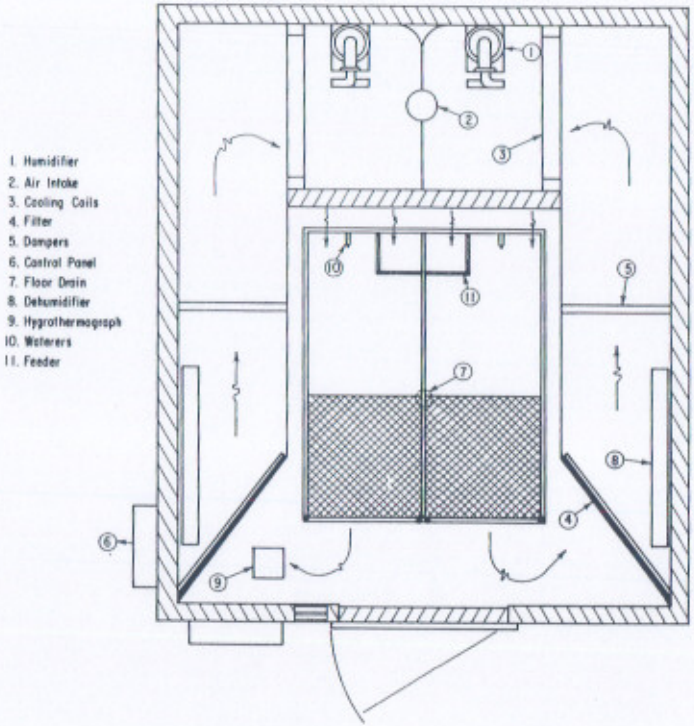


Figure 2. Environmental chamber showing restraining crate and environmental equipment.

day 6 for each week of pig confinement. Chamber temperatures and humidities were also obtained at these same times from a continually operating hygrothermograph recorder located inside each chamber.

Results and Discussion

The means and standard deviations for the cool and hot chamber temperatures and relative humidities are given in Table 1.

Chamber temperatures and the hot chamber humidities were relatively constant during this experiment. However, the dehumidification system in the 70°F. chamber was operating at full capacity during the entire study. In weeks two and four fluctuations in humidity were noted which possibly resulted from increased air moisture outside the chamber. It was possible to control humidity at 60 percent in the hot chamber

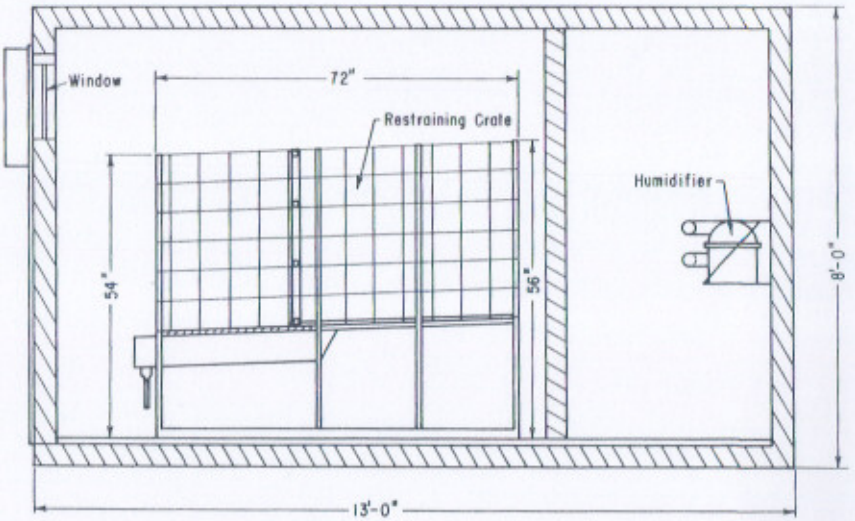


Figure 3. Cross section of environmental chamber showing restraining crate design.

Table 1. Means and Standard Deviations for Chamber Temperature and Relative Humidity

Chamber	Temperature (°F.)		Relative Humidity (%)	
	Mean	St. Dev.	Mean	St. Dev.
Cool	69.9	0.86	61.5	2.74
Hot	84.8	0.49	60.3	1.41

because the high temperature was a supplement to the dehumidification system. This suggests that the environmental facilities would be relatively inefficient in obtaining relative humidities below 60 percent in the 70°F. environment used in this study. However, the 5 m.p.h. wind velocity for this experiment could have been too slow to circulate sufficient air through the dehumidifier. In future trials where low temperatures and humidities are desired it may be desirable to increase wind velocity above 5 m.p.h. or install a larger dehumidification system.

One gilt exposed to the hot chamber during the fourth week exhibited abnormally high rectal temperatures and respiration rates and was subsequently eliminated from this study. Four gilts in the cool chamber and 6 gilts in the hot chamber were observed to be in estrus on either

the third or fourth day of confinement. This increased incidence of estrus may have resulted from the environmental change and the physical stress of moving to the chamber location. Nalbandov (1964) noted that more pigs when moved will exhibit estrus within 5 to 8 days than would have in their original location.

As chamber temperature was increased to 85°F., rectal temperatures and respiration rate increased. The average cool and hot rectal temperatures were 102.4°F. and 103.0°F., respectively. A temperature of 102.4°F. is considered normal for pigs. The 103.0°F. average hot rectal temperature suggests that these gilts were in an environment above their comfort zone.

The average cool chamber and hot chamber gilt rectal temperatures are presented by time intervals in Figure 4. This figure indicates that a diurnal rectal temperature rhythm was exhibited by pigs in both chambers with lows occurring at 6:30 a.m. daily. Average rectal temperature increases were observed for both gilt groups after feeding at 6:30 a.m. each day. The control gilts tended to be more active and to consume their feed prior to the 10:30 a.m. reading, while the hot chamber pigs were observed to be eating over a 24 hour period. The gilts in the hot chamber appeared to adapt to heat stress about the fourth or fifth confinement days as evidenced by non-significant differences between the rectal temperatures of the cool and hot groups.

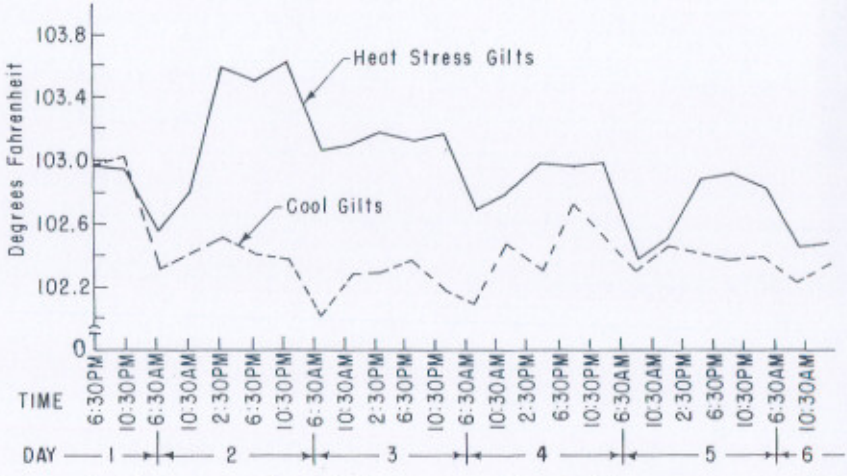


Figure 4. Average cool and heat stress gilt rectal temperature comparisons at different stages of confinement.

Both gilt groups exhibited average high rectal temperatures at 2:30 p.m., 6:30 p.m. or 10:30 p.m. on days 2, 3, 4 and 5 of the confinement period. These rectal temperatures were averaged to obtain a daytime high rectal temperature and are presented in Figure 5. Average daytime high hot rectal temperature was significantly ($P<.01$) higher than the average daytime cool rectal temperature for either day 2, 3, 4 or 5 of exposure. The greatest reduction in rectal temperatures for heat stress gilts occurred from day 2 to 3 of confinement. The increase for average daytime high cool rectal temperature on day 4 was possibly the result of the four cool chamber gilts coming into estrus on the fourth confinement day and exhibiting rectal temperature increases. This response was not evident among the hot chamber pigs although six gilts did show signs of estrus on either the third or fourth confinement day.

The cool and hot chamber gilt average respiration rates are presented by time intervals in Figure 6. As chamber temperature was increased to 85°F. the average respiration rate for the hot chamber pigs was higher ($P<.01$) than the average respiration rate for those pigs in the cool environment at every time period for the remainder of the week. However, there was a trend for the daytime high average hot chamber gilt respiration frequency to decrease with length of exposure.

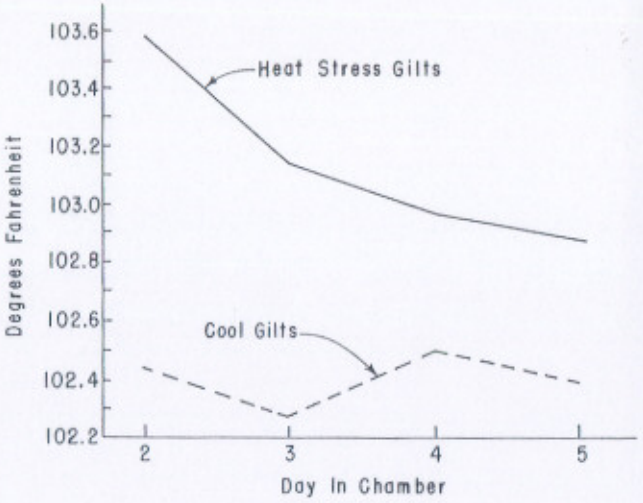


Figure 5. Average daytime high (2:30, 6:30 and 10:30 p.m.) rectal temperature comparisons for cool and heat stress gilts on days 2, 3, 4 and 5 of confinement.

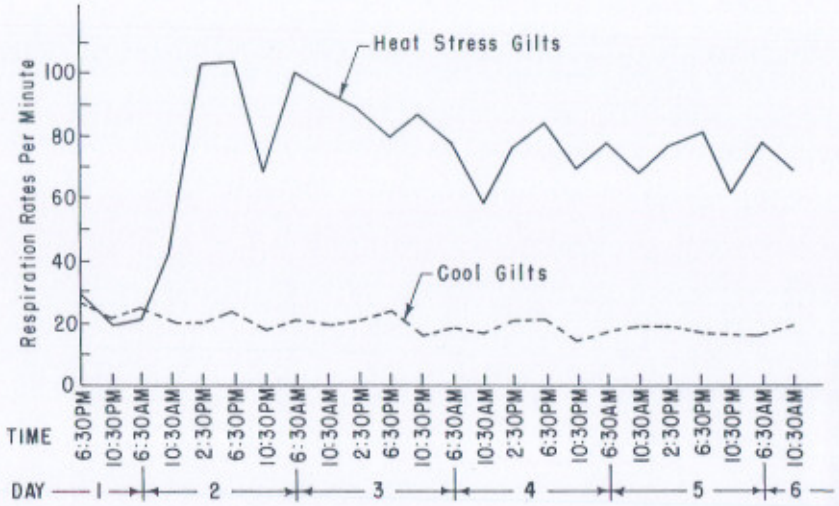


Figure 6. Average cool and heat stress gilt respiratin rate per minute comparisons at different stages of confinement.

There was also a tendency for both gilt groups to exhibit daytime fluctuations in average respiration rates.

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Pelleting Milo and Wheat for Growing-Finishing Swine

Benny S. Robbins, W. G. Luce and I. T. Omtvedt

Story in Brief

Three hundred twenty-four pigs were fed during the summer of 1970 at the Fort Reno Livestock Research Station to compare pelleted and ground all milo, 50 percent milo-50 percent wheat and all wheat-soybean meal diets for growing-finishing swine. The pigs were self-fed in confinement from an average weight of 52.9 to 210.8 pounds.

Pelleting significantly improved average daily gains and feed efficiency for either the milo, wheat or milo-wheat mixture when compared to the ground diets. The wheat or wheat-milo mixture supported similar gains and feed utilization as the milo ration.

Introduction

The influence of different processing methods of milo and wheat for swine on performance and feed utilization have not been fully established. Information involving pelleting is needed in order to most efficiently utilize milo and wheat in growing-finishing swine rations.

Milo has been considered the traditional swine feed in Oklahoma, but in recent years, wheat has been competitively priced with other cereal grains and used as a feed for swine. This has created the need for more information on the effect of substituting wheat for milo in growing-finishing rations.

The purposes of this study were to compare pelleting with grinding and to study the effect of substituting wheat for milo in diets for growing-finishing swine.

Materials and Methods

Three hundred twenty-four Duroc, Beltsville, and crossbred pigs from the swine breeding project at Fort Reno were self-fed in confinement during the summer of 1970 from an average weight of 52.9 to 210.8 pounds. Eighteen pigs were randomly allotted within breed, sex, litter, and weight to each pen (nine barrows and nine gilts; three Durocs, three

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Beltsvilles and three crossbreds). The study included three replications, each started one week apart, of the six treatments involving 18 pens.

The pigs were fed 16 percent crude protein all milo, 50 percent milo-50 percent wheat or all wheat-soybean diets as shown in Table 1. Each diet was fed in both ground and pelleted form. The milo and wheat analyzed 8.3 and 12.3 percent crude protein, respectively. A proximate analysis of the complete rations showed 87.7, 88.9, and 88.0 percent dry matter and 16.3, 15.4, and 16.5 percent protein for the milo, wheat and 50 percent milo-50 percent wheat diets, respectively. The pigs were started on one of the six experimental diets one week after being placed in 10′ x 24′ feeding pens with concrete floors. This allowed pigs time to adjust to the new surroundings before the trial started. The pigs had access to feed and water at all times.

All grains were ground by using a hammermill with a 0.125 inch screen. The three ground diets were fed in this finely ground form, while the pelleted diets were fed as 3/16 inch pellets.

The pigs were individually removed from the six treatments at approximately 210 pounds. Average daily gain, daily feed intake, feed efficiency, and probed backfat thickness adjusted to 200 pounds were calculated at the completion of each trial.

Table 1. Ration Composition.

Ingredients, percent	Ration Number[1]		
	1 and 2	3 and 4	5 and 6
Milo (8.3%)	72.25	----	38.25
Wheat (12.3%)	----	81.50	38.25
Soybean meal (44%)	22.75	13.60	18.50
Molasses (wet)	1.50	1.50	1.50
Dicalcium phosphate	1.50	1.30	1.40
Calcium carbonate	0.80	0.90	0.90
Salt	0.50	0.50	0.50
Vitamin-trace mineral premix[2]	0.50	0.50	0.50
Tylan 10	0.20	0.20	0.20
Total	100.00	100.00	100.00
	Calculated Percent		
Composition			
Protein	16.00	16.00	16.00
Calcium	0.70	0.70	0.70
Phosphorus	0.60	0.60	0.60

[1] Rations 1, 3, and 5 were fed in ground form. Rations 2, 4, and 6 were fed in pelleted form.
[2] Vitamin-trace mineral premix 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.

Results and Discussion

The results of this trial are shown in Table 2. The pigs receiving the ground or pelleted diets were fed an average of 96.3 and 90.8 days, respectively. The average daily gains and feed efficiencies of the pigs fed the pelleted diets were significantly superior to those of pigs fed the ground diets. Pigs fed pelleted diets also tended to have a lower average daily feed intake. No significant differences in performance were found due to the grain within the ground or pelleted diets. Treatments also had little apparent effect on probed backfat thickness.

Table 2. Effect of Pelleting on Performance of Growing-Finishing Swine.

	Ration Designation					
	Milo		Wheat		50% Milo-50% Wheat	
Item	Gr. 1	Pel. 2	Gr. 1	Pel. 2	Gr. 1	Pel. 2
Pens per treatment, no.	3	3	3	3	3	3
Pigs per pen, no.	18	18	18	18	18	18
Av. initial weight, lb.	53.5	52.3	53.1	52.8	52.0	53.7
Av. final weight, lb.	210.0	211.1	209.9	211.2	207.3	215.3
Av. daily gain, lb.*	1.64[1]	1.77[2]	1.61[1]	1.74[2]	1.67[1]	1.75[2]
Av. daily feed intake, lb.**	5.73[3]	5.60[2,3]	5.42[1,2]	5.29[1]	5.66[2,3]	5.34[1]
Feed per lb. of gain, lb.*	3.51[2]	3.17[1]	3.42[2]	3.07[1]	3.50[2]	3.12[1]
Av. adjusted backfat, in.	1.48	1.49	.148	1.49	1.50	1.51

* Any two means without a common superscript differ significantly ($P<.01$).
** Any two means without a common superscript differ significantly ($P<.05$).

Myodegeneration Syndrome In Swine

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Story In Brief

In recent years there has been noted an increased death rate of swine as a result of medical treatment, weighing, lot movement, exercise, and hauling. This increase in death rate has been attributed to a muscle abnormality known as Myodegeneration Syndrome. The purpose of this

research is to facilitate the separation of normal from Myodegeneration Syndrome susceptible animals by means of a rapid detection method utilizing measurements of serum Creatine Phosphokinase (CPK) level in the blood.

In the first study 40 Yorkshire pigs were used, twenty castrated males and 20 females. CPK determinations were made when the pigs were 3 months of age. The animals were then exercised on a treadmill and the CPK determination was repeated. After reaching 5 months of age, 6 pigs which had excessive elevations of CPK were slaughtered along with 6 animals which were considered to be normal. In order to determine the effectiveness of the method, detailed histological, gross, histochemical, chemical, and physical analyses were run on samples taken from the major loin muscle, the longissimus dorsi. Animals with the highest levels of CPK typically exhibited low initial pH in the range of 5.35 to 5.99 in the muscle tissue, very low scoring with regard to quality points such as color, marbling, and firmness, greater than normal fiber diameter, moisture, and shear values. Muscle temperature markedly increased reaching an average of 106.5°F. The lean cut yield was much higher in susceptible animals as compared to those animals classified as normal.

Introduction

Myodegeneration Syndrome has become a major problem in today's meat industry. The difficulty is to some degree the fault of the consumer who is pressuring the industry for not only more but a higher quality of meat both in the raw and cooked form. The food industry must realize that the shopper of today has become quite an educated buyer and it must strive to meet his demands. Realizing the scope of the problem, the swine producer has managed to provide animals with not only more but a higher quality meat through selective breeding, enriched feeds, or by a combination of the two. As a general rule, his efforts have succeeded, but exceptions may be drawn to any rule. Such is the case with Myodegenerations Syndrome.

It appears the meatier the animals, the more susceptible they are to the disease and the lower their quality. Animals which are Myodegeneration Syndrome susceptible are characterized by gasping, open mouth breathing, elevated body temperature, tensed back muscles, and show evidence of stiffness. Immediately after slaughter, the pigs exhibit severe rigor mortis and the muscles of the carcass are typically light in color, lacking firmness, and exude water. Such conditions in the live animal may ultimately result in death before slaughter or cause the carcass to be of such a poor quality as to be unacceptable to the consumer both in the raw and cooked form. If the pork industry expects to meet current de-

mand for high quality it becomes apparent that there is a great need for a method of rapid detection of animals which are susceptible to the Myodegeneration Syndrome.

Because the enzyme Creatine Phosphokinase (CPK) is found primarily in muscle tissue it was chosen as the best means of diagnosis. CPK was introduced as a diagnostic aid by Ebashi et al., and Dryfus et al., 1959 and 1960. Since the time of the introduction of CPK as a detection methods, it has received much attention in Europe, whereas few reports have been noted in the United States literature. Most work has been reported on muscular disorders in the human.

The enzyme Creatine Phosphokinase catalyzes the reversible reaction:

$$\text{Creatine} + \text{ATP} \xleftrightarrow[\text{Mg}++]{\text{CPK}} \text{ADP} + \text{Phosphocreatine}$$

Hence one can see that this reaction is a valuable source of energy, furnishingATP, particularly in muscle which has been forced to metabolize anerabically (absence of oxygen).

Several methods are available for the determination of serum CPK activity. The method used in this study is based on the technique of Tanzer and Gilvarg (1959). With this method, the primary reaction is coupled to two subsequent reactions:

$$\text{ATP} + \text{Creatine} \xleftrightarrow[\text{Mg}++]{\text{CPK}} \text{ADP} + \text{Creatine Phosphate}$$

$$\text{ADP} + \text{Phosphoenolpyrvate} \xleftrightarrow{\text{PK}} \text{Pyrvate} + \text{ATP}$$

$$\text{Pyrvate} + \text{DPNH} \xleftrightarrow{\text{LDH}} \text{Lactate} + \text{DPN}$$

Conversion of DPNH to DPN results in a decreased absorbance of the solution when measured at a wavelength of 340 mu. The amount of enzymatic activity is proportional to- the rate- of- oxidation- of- DPNH ——————→ DPN in the unknown measured against a blank. Under test conditions, one international unit of CPK activity will result in the oxidation of 1 micromole of DPNH/min/ml of the serum at pH 9 and 25°C. Normal ranges of CPK activity in other muscular disorders were found to be between 0 and 8 x 10^{-4} international units. Levels above 17 x 10^{-4} are considered to be abnormal (Hess et al., 1964). Studies by Vester et al., 1968 and Henson et al., 1966, showed that an elevation of CPK appears to exist for most diseases of skeletal muscle. Hopefully the use of CPK level of the blood will afford a rapid and accurate detection of diseased animals.

Procedure

In order to evaluate the efficiency of the blood CPK technique a detailed study of the muscle tissue was undertaken:

A. Evaluation of the carcass:
   1. Determinations of the amount of total muscling were made.

B. Evaluation of the Longissimus dorsi:
   1. The L. dorsi muscle was scored as to quality such as color, firmness, and marbling.
   2. Histological aspects were determined such as fiber diameter, degree rigor, sarcolemma thickness, nuclei number, length, and width, and the overall condition of the fibers.
   3. Histochemical examination utilizing NADH-TR (Nicotinamide Adenine Dinucleotide-Tetrazolium Reductase) in a technique described by Engel et al., 1965.
   4. Chemical determination of pH, moisture, and lipid.
   5. Physical evaluation utilizing shear force as a parameter for tenderness.

Results

In order to understand some of the causes of the Myodegeneration Syndrome it is essential that one have a working knowledge of muscle anatomy. Muscle is a highly complex tissue when viewed with the aid of the light microscope. It may be seen that the muscle is actually composed of bundles of fibers of varying degree of roundness. Within any given muscle there are essentially three basic types of fibers, red, white, and intermediate, which have their own physiological activities. The white fiber is described as being fast-contracting and metabolizes stored glycogen anaerobically yielding lactic acid as a waste product. Then there is the slow-contracting red fiber which metabolizes aerobically and possesses a Kreb's cycle and cytochrome system.

The last type of fiber is described as being intermediate in nature and is able to metabolize both anerobically and aerobically. Fibers posessing the Krebs and cytochrome system are able to synthesize 30 ATP molecules per glucose while those metabolizing via glycolysis yield only 2 ATPs per glucose molecule. Cooper et al., 1969, noted that the white fiber area expressed as a percent of total fiber area was 70-75 percent while the remaining 25-30 percent was composed of red and intermediate fibers in normal porcine muscle. It was also observed that one of the differences in normal and abnormal muscle was the distribution of certain fiber types. The fiber type affects post-mortem metabolism and this variable rate of post-mortem metabolism has important implications in the

ultimate usefulness of muscle as a food. In abnormal porcine muscle various scientists have noted that there is a much higher distribution of white and especially intermediate fibers.

It is also postulated that animals have the Myodegeneration Syndrome have lower capillary distributions and therefore lower myoglobin contents and that this effectively reduces the oxygen supply and storage in the muscle tissue. In an environment such as this muscles undergo a more rapid and severe oxygen debt. Due to the abnormal ratio to white and intermediate fibers, the muscle accumulate lactic acid in higher concentrations than normal, causing a rapid fall in pH during stress situations and post-mortem.

Rapid pH decline would be almost fatal to the delicate sarcoplasmic and myofibular proteins. The lack of oxygen also causes a "shut-down" of the cytochrome system so that the main source of energy to the muscle is lost. The muscles are forced to synthesize ATP, the energy source for contraction, via creatine phosphate. Once this reserve is drained no more ATP is available to facilitate relaxation, thus bringing about sudden rigor mortis noticed in several of the animals upon slaughter. In general this abnormal metabolism has a very detrimental effect on the muscle and hence meat quality.

As noted in Table 1, the level of CPK in the blood depended upon the individual animal and the degree of stress received prior to blood sample removal. As would be expected, the level of CPK increased following exercise, however some animals seem able to adapt readily to stress.

Table 2 shows the effect of Myodegeneration Syndrome on the carcass tissues. Animals with high lean cut yield were directly related to in-

Table 1. Creatine Phosphokinase Level of Porcine Blood Before and After Exercise.

Hog No.	Mild Exercise[1]		Severe Exercise[2]	
	CPK-1	CPK-2	CPK-3	CPK-4
11-3	230	550	53	—
14-8	45	73	32	79
15-4	48	65	9	51
15-6	71	240	72	76
15-7	130	270	33	102
16-7	112	345	730	520
17-1	112	93	74	1310
17-8	28	230	116	485
17-10	122	469	150	1075
18-9	60	49	88	95
20-8	71	62	24	40
20-10	50	35	10	38

[1] Mild exercise involved driving the pigs around the pen for 20 minutes.
[2] Severe exercise involved stress from exercise on the tread mill and ambient heat (80-85°F).

Table 2. The Effect of Myodegeneration Syndrome on the Porcine Carcass

Animal Number	Live Wt.	Chilled Side Wt.	Carcass Lean Cut Yield %	Live Lean Cut Yield %	Carcass Length (Inch)	Fat Thickness (Inch)	Muscle Temperature Deg. F.
11-3	Died	–	–	–	–	–	–
15-4	228	81.5	61.10	43.68	31.70	1.40	106.4
16-7	235	82.7	69.22	42.38	30.30	1.47	106.4
17-10	226	82.3	57.84	42.12	29.20	1.50	106.9
17-1	215	79.2	59.47	43.81	30.10	1.37	106.0
Normal							
14-8	222	79.6	56.91	40.81	31.00	1.27	–
15-6	232	81.7	53.98	38.02	30.70	1.43	–
15-7	226	78.2	55.80	38.67	31.00	1.57	105.5
17-8	242	84.0	56.55	39.26	30.80	1.60	106.0
18-9	220	75.5	55.1	37.82	31.60	1.47	105.0
20-8	231	78.7	56.42	38.44	31.30	1.40	104.0
20-10	222	78.9	57.54	40.90	31.00	1.23	–

creased levels of CPK and low quality pork. As may be noted, animals with the higher CPK value also possessed elevated temperatures.

Comprehension of the detrimental effect the disease has on muscle is enhanced by Table 3. Associated with the myodegeneration syndrome is a loss of meat quality. Various muscles of the carcass have a pale color, and lack firmness. Due to the anerobic type of metabolism, there is little fat synthesis, hence little intramuscular fat deposition in the form of marbling. The high ratios of white and intermediate fibers caused the tissue to be more acidic due to large amounts of lactic acid which accelerated the rate of pH decline. Most abnormal animals are characterized by a muscle pH of 5.5 or below, 30 minutes post-mortem. Those muscles that have greater amounts of red fibers have a pH of 6.0 or higher at, 60 minutes post-mortem.

A detailed analysis of the major loin muscle (longissimus dorsi) further substantiated practical measures for leanness. In general loin eye area and muscle weight were greater in these animals termed abnormal. Table 4. Fiber diameter was not found to be associated with meatiness, but may be associated with muscle degeneration. Degree of fiber rigor and animal stiffness may well be associated. It is interesting to note that the percent of fat as determined by ether extract was, on the average, lower in the abnormal animals.

Examination of cross-sections of the longissimus dorsi stained with NADH-TR yielded three very interesting facts. There is an extreme difference between the size of normal and abnormal muscle fibers. These animals which are Myodengeneration Syndrome susceptible posessed a higher amount of white and intermediate fibers. In normal muscles the red fibers were concentrated in the center of the fasciculus with the intermediate fibers surrounding them, the white fibers being on the exterior. In abnormal muscles there seemed to be a lack of organization of the fiber types as they were scattered throughout the fasciculus in a haphazard arrangement. Also there was noted in the high serum CPK pigs a "giant fiber" which has also recently been described by Cassens (et al., 1969). This fiber measured some 150 microns in diameter and was found to be in every one of the abnormal animals examined. Consequently, the histochemical analysis may prove to be a very useful parometer.

Summary

Preliminary investigations using 12 pigs showed that there may be a relationship between abnormally high serum CPK levels in the blood and susceptibility to the Myodengeneration Syndrome. The technique will be used to eliminate those animals which have already developed the disease and those which are susceptible to it.

Table 3. The Effect of Myodegeneration Syndrome on Porcine Meat Quality

Animal Number	Color Score	Firmness Score	Marbling Score	Shear Value lb.	Moisture Value %	Fat %	Initial pH	Final pH
11-3	–	–	–	–	76.31	0.20	–	–
15-4	pale (2)	soft (2)	scant (2)	17.5	74.77	0.13	5.99	5.20
16-7	ext pale (1)	very soft (1)	devoid (1)	16.4	74.39	0.19	5.35	5.21
16-7	pale (2)	soft (2)	scant (2)	23.4	75.69	0.26	5.50	5.38
17-1	sli pale (3)	sli firm (5)	scant (2)	21.4	75.68	0.62	6.60	5.64
Normal								
14-8	mod pink (4)	sli firm (5)	scant (2)	–	72.75	0.20	6.52	5.62
15-6	mod pink (4)	sli firm (5)	scant (2)	–	72.75	0.13	6.42	5.60
15-7	mod pink (4)	firm (6)	mod(5)	15.4	74.82	0.18	6.56	5.59
17-8	mod pink (4)	avg (4)	sli (3)	14.8	73.27	0.19	6.10	5.25
18-9	sli pink (3)	firm (6)	mod (4)	20.5	73.00	0.42	6.74	5.25
20-8	mod pink (4)	sli firm (5)	sli (3)	15.5	73.76	0.21	6.65	5.25
20-10	sli pink (3)	avg (4)	sli (3)	–	73.70	0.28	6.65	5.55

Table 4. The Effect of Myodegeneration Syndrome on the Porcine Longissimus Dorsi Muscle

Animal Number	LD Area (Sq. In.)	LD Weight lb.	Fiber Diameter μ	Degree Rigor %	Nuclei Length μ	Nuclei Width μ
11-3	–	–	–	–	9.57	4.96
15-4	5.50	5.20	79.80	1.69	11.69	4.35
16-7	6.15	5.20	58.80	1.36	13.32	2.95
17-10	5.51	4.80	68.70	3.84	12.12	3.26
17-1	6.45	5.40	88.20	3.62	15.88	2.87
Normal						
14-8	4.18	4.60	70.98	1.86	12.53	3.01
15-6	4.38	4.60	73.80	2.10	11.19	2.76
15-7	4.64	4.60	63.60	1.60	15.02	2.94
17-8	5.57	5.20	74.30	2.26	11.09	3.43
18-9	4.04	3.80	77.20	2.52	10.37	4.06
20-8	4.69	4.20	75.00	1.80	17.29	2.73
20-10	4.92	4.60	68.40	2.04	13.93	2.68

Muscle tissue from animals with the syndrome is very soft, high in moisture, and light in color. Animals possessing the syndrome are quite meaty but lack sufficient deposits of intramuscular fat. Abnormal muscle also exhibited very low pH at 1 hour post-mortem.

Although not enough data is yet available to substantiate many of these statements, one fact is obvious: Myodegeneration Syndrome has a very undesirable effect on the quality of pork and its eventual usefulness as a food.

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High Moisture Milo For Swine

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Story In Brief

Two trials were conducted to evaluate the relative merit of ground, reconstituted-rolled and dry rolled milo-soybean diets for growing-finishing swine.

In trial number 1, no significant differences in rate of gain or feed utilization were obtained among pigs fed the three milo treatments. However, pigs fed the ground milo diet tended to require less feed per pound of gain than pigs fed the reconstituted-rolled or dry rolled milo diets.

In trial two, pigs fed the reconstituted diet required significantly less feed per pound of gain and consumed significantly less feed per day than pigs fed the ground or dry rolled milo diets. No significant differences in average daily gain were noted among pigs fed the three diets, but pigs fed the ground milo diet tended to gain faster than pigs fed the reconstituted-rolled or dry rolled milo diets.

Introduction

Methods of processing are continuously being studied in an attempt to improve the feeding value of ceral grains and performance of swine. Recently, high moisture reconstitution has been compared with dry pro-

cessing methods as a means of improving rate of gain and feed utilization. A substantial improvement in feedlot performance has been obtained with cattle fed reconstituted milo as compared to dry milo. Preliminary trials involving growing-finishing swine have shown that pigs fed reconstituted or high moisture harvested grain diets required less feed per pound of gain than pigs fed dry grain diets.

Since milo has been the traditional swine feed in Oklahoma, two trials were conducted to study the effects of feeding reconstituted, high-moisture-rolled, ground or dry rolled milo to swine. The performance of pigs on each trial was used to compare the three processing methods.

Materials and Methods

In trials 1 and 2, 42 and 48 purebred Yorkshire and Hampshire pigs were self-fed in confinement 52.8 and 91.1 days from an average weight of 120 to 203.7 pounds and from 57.8 to 211.3 pounds, respectively. Trials 1 and 2 were conducted during the summer and winter of 1969, respectively. The pigs were obtained from the Oklahoma State University swine herd and were randomly allotted within breed, sex and weight to three treatments.

The pigs were fed 16 percent crude protein, milo-soybean meal diets in two-pig, 6′ x 7′ feeding pens with concrete floors. The experimental diets were identical except for the preparation of the milo. The milo was either ground, reconstituted and rolled or dry rolled before mixing into the complete ration, shown in Table 1.

Table 1. Ration Composition[1]

Ingredient	Percent
Milo	76.98
Soybean Meal (50%)	19.67
Calcium carbonate	0.50
Dicalcium phosphate	1.85
Trace mineral salt[2]	0.50
Premix 8650A[3]	0.50
Total	100.00

Five pounds of antibiotic supplement[4] were added per ton of ration

[1] Ration composition based on a 90% dry matter basis.
[2] Trace mineral salt supplied 12.5 ppm manganese, 10 ppm iron, 5 ppm sulfur, 1.65 ppm copper, 0.5 ppm cobalt, 0.35 ppm iodine and 0.25 ppm zinc per pound of diet.
[3] Premix 8650A supplied 1000 I.U. vitamin K, 100 I.U. vitamin D, 1.1 mg. riboflavin, 10 mg. niacin, 3.15 mg. pantothenic acid, 52.5 mg. choline, 7.5 mcg. vitamin B_{12}, 1.2 ppm iodine, 11 ppm manganese, 22 ppm iron, 2.5 ppm copper, 0.3 ppm cobalt and 72.2 ppm zinc per pound of diet.
[4] Antibiotic suplement contained 20 gm. aureomycin, 10 gm. sulfamethazine and 20 gm. penicillin per pound.

The reconstituted-rolled milo was prepared by adding 15 gallons of warm water to 200 pounds of air-dry, whole milo. This mixture was allowed to mix for 45 to 50 minutes in a cement mixer to raise the moisture level of the milo to 30-32 percent. The grain was sacked in plastic airtight bags and stored for 21 days. After this time the milo was removed from the bags, rolled between 18" x 24" rollers with a 0.001 inch roller tolerance, mixed, resacked and placed in a 34°F. cooler until fed.

Ground milo was prepared by using a hammermill with a 0.1875 inch screen. Dry rolled milo was prepared by rolling the grain between 18" x 24" rollers with a 0.001 inch roller tolerance.

The complete reconstituted-rolled, ground and dry rolled milo-soybean diets contained approximately 74.07, 87.17 and 84.32 percent dry matter, respectively.

Results and Discussion

The results of Trial 1 are shown in Table 2. The data suggested that the preparation methods used did not significantly effect daily gain, daily feed intake or feed per pound of gain. As shown in Table 2 the daily gains of pigs fed the ground or dry rolled milo diets tended to be superior to those of pigs fed the reconstituted milo diet. Pigs fed the ground diet tended to eat less and to be more efficient than pigs fed the high moisture or dry rolled diets.

The results of Trial 2 are shown in Table 3. No significant differences were obtained for rate of gain of pigs fed the three diets, but feed utilization was significantly improved for pigs fed the reconstituted milo diet. As shown in Table 3 pigs fed the ground milo diet tended to gain

Table 2. Effect of Reconstituted Milo on Performance of Finishing Swine

Item	Ration Designation		
	1 medium grind	2 reconstituted rolled	3 dry rolled
Pens per treatment, no.	7	7	7
Pigs per pen, no.	2	2	2
Average initial weight, lb.	122.9	119.4	120.4
Average final weight, lb.	204.3	202.6	204.1
Average daily gain, lb	1.75	1.67	1.64
Average daily feed intake, lb.[1 2]	5.94	5.08	5.90
Feed per pound of gain, lb.[1 2]	3.08	3.33	3.42

[1] Values shown were corrected to a 90 percent dry matter basis.
[2] No significant differences ($P \geq .05$) between treatment means.

Table 3. Effect of Reconstituted Milo on Performance of Growing-Finishing Swine

Item	Ration Designation		
	1 medium grind	2 reconstituted rolled	3 dry rolled
Pens per treatment, no.	8	8	8
Pigs per pen, no.	2	2	2
Average initial weight, lb.	61.0	57.9	54.6
Average final weight, lb.	212.3	210.6	210.9
Average daily gain, lb.	1.75	1.67	1.64
Average daily feed intake, lb [1] [2]	5.94[2]	5.08[1]	5.90[2]
Feed per pound of gain, lb.[2]	3.37	3.01[1]	3.54[2]

[1] Values shown were corrected to a 90 percent dry matter basis.
[2] Any two treatment means without a common number differ significantly ($P \leq .05$).

faster than pigs fed the reconstituted or dry rolled milo diets. Pigs fed the reconstituted diet required less feed per pound of gain and consumed less feed than pigs fed the ground or dry rolled milo diets. Part of the improvement in feed utilization of pigs fed the reconstituted diet appeared to be due to less feed wastage.

The data obtained from these two studies are inconsistent in that improvement in efficiency of gain was obtained only in Trial 2. Reasons for this inconsistency were not elucidated. It is noteworthy, however, that Trial 1 was conducted during the summer months when spoilage was a problem whereas trial 2 was conducted during winter.

Additional studies with high moisture milo for swine are currently being conducted.

The Relationship of Darkness and Confinement to Early Rebreeding of Spring Lambing Ewes

Joe V. Whiteman, Mike B. Gould and S. V. Tennery

Story in Brief

During the fall of 1968 a group of 113 ewes were bred to lamb between March 15 and April 5, 1969. As ewes and lambs were removed from lambing pens three days after lambing they were alternately placed in a dark, confined area or in a regular barn-night lot environment until 25 days after lambing. As the ewes in each group reached the 25 days after lambing stage, they and their lambs were removed from their treatment group, turned to pasture and exposed to fertile rams until June 30. Mating behavior indicated essentially no treatment effect on the occurence of estrus during the breeding period. Lambing records indicated that the conception rate and interval from lambing to conception was practically the same for the two groups. Thus, the experiment indicated that the use of darkness and confinement immediately after lambing apparently had no beneficial effect on spring lambing ewes in terms of getting them to breed back sooner.

Introduction

A four year study involving efforts to breed Dorset, Rambouillet and Dorset X Rambouillet crossbred ewes twice-yearly clearly demonstrated that under natural conditions ewes that lambed in March and April did not breed back for fall lambing very readily. Only about 23 percent of the ewes conceived after lambing in the spring and the average interval from lambing to conception was about 66 days for those that did conceive. These results suggest then that management practices

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need to be discovered that will increase the proportion of ewes conceiving and shorten the interval from lambing to conception if possible.

It was decided to conduct a study to determine if light control and/or confinement of ewes immediately after lambing would hasten rebreeding. These factors were selected for study for several reasons. First, it has been reported on many occasions that reducing the amount of daylight gradually during the spring will improve the out-of-season the experimental flock at Ft. Reno, a group of ewes that were confined and subjected to different light conditions for most of the first 25 days after lambing mated and conceived better than a similar group of ewes that were neither confined nor subjected to restricted light during the same period of time. Third, research in Virginia showed that ewes confined after lambing mated and conceived rather readily when lambs were weaned and ewes were turned to pasture 30 days after lambing.

This paper reports an experiment conducted during 1969 to determine whether spring lambing ewes exposed to darkness and confinement for a period of time after lambing would rebreed for fall lambing any better than similar ewes not confined nor subjected to darkness.

Materials and Methods

The experimental plan was to determine if placing ewes in a very dark area under close confinement for the period starting three days after lambing and extending until 25 days after lambing would cause them to breed back sooner than similar ewes exposed to normal light and allowed to move in and out of the barn.

The ewe flock available was composed of 35 Dorset, 91 Rambouillet and 81 Dorset X Rambouillet crossbred ewes. This entire flock was exposed to rams for 20 days starting on Octoger 20, 1968 in order to get a large number of ewes to lamb during a short period of time during late March and early April. In spite of the fact that 70 of the ewes had lambs at side, 113 ewes conceived and lambed between March 15 and April 5, 1969.

As ewes lambed they were placed in lambing pens where lambs were weighed and identified. Three days after lambing each ewe with her lamb (s) was assigned to either the dark group or the control group taking care to have the breed groups equally represented on both treatments. Also an equal number of twin rearing ewes were placed on each treatment. The two groups of ewes were fed the same ration during this period.

Twenty five days after each ewe lambed she and her lamb (s) were removed from the treatment group and placed out on pasture with a ram. The rams were equipped with marking harnesses to permit record-

ing of mating behavior. The ewes were observed each morning and the ewes that had mated were recorded. In this manner it was possible to determine the time interval from lambing to estrus for each ewe that showed estrus before June 30 at which time the breeding season ended. This procedure permitted a ewe that lambed on March 15 a period of 107 days to show estrus and a ewe that lambed on April 5 and 87 days to return to estrus before the rams were removed.

The ewes were kept under normal conditions and lambed out during the fall of 1969. Lambing records could then be compared to mating records and a determination made as to which matings resulted in conceptions.

Results

The comparison of the behavior of the two groups of ewes is summarized in Table 1. There were 56 ewes in the dark and confined group and 57 ewes in the control group. An equal number, 42, of the ewes in each group mated some time during the April to June breeding season. The average interval from lambing to first mating of the ewes that mated was almost identical for the two groups, 58 and 57 days respectively for the dark and the control group respectively.

The lambing records indicated that the conception rates were also very similar. Of the 42 dark and confined ewes that showed estrus (mated), 23 conceived at their first estrus and 34 or 67 per cent conceived altogether. This was comparable to the control ewes where of 42 ewes showing estrus, 24 conceived at first estrus and 31 or 54 percent conceived during the mating season.

Table 1. Summary of Mating and Lambing Performance of Spring Lambing Ewes Exposed to Darkness and Confinement vs. Normal Light and Space

	Dark Confined	Normal
No. ewes	56	57
No. ewes showed estrus	42	42
Av. interval to 1st estrus (da.)[1]	58	57
No. ewes conceived 1st estrus	23	24
No. ewes conceived (total	34	31
% ewes conceived (%)	61	54
Av. interval to conception da.	65	62
Lambing rate[2]	1.29	1.32

[1] Days from lambing to first estrus for those ewes that showed estrus.
[2] Lambs born per ewe lambing.

One of the most serious problems of multiple lambing involves trying to get ewes to mate soon after lambing. Previous experience had indicated an average interval of 66 days from lambing to conception for those ewes that did conceive after lambing in March and April. The two groups of ewes in this experiment demonstrated about the same performance. The interval was 65 days for the ewes on the dark treatment and 62 days in the control group. Thus, we have no suggestion that darkness used as in this experiment will aid in shortening the postpartum interval in the spring.

The lambing rates were also very similar for the two groups of ewes with no suggestion that the dark and confined group benefitted from this treatment.

These overall results do not suggest that darkness or confinement as used in this experiment has much if anything to contribute to solving the problem of getting spring lambing ewes to breed back quickly. The results from 1967, quoted earlier, had shown a great improvement in the number of spring lambing ewes that bred back after lambing in the spring with little change in the average interval from lambing to conception. The results of this experiment also indicated that over half of the ewes bred back after lambing between March 15 and April 5 but the average interval from lambing to conception, for those ewes conceiving, was over 60 days.

It would appear that other factors that might influence the postpartum interval should now be investigated.

Effects of Early Weaning on Subsequent Rebreeding in Spring Lambing Ewes

M. B. Gould, S. V. Tennery ad J. V. Whiteman

Story in Brief

In the spring of 1970, the lambs of 36 ewes were weaned at 30 days of age while the lambs of 36 other ewes (control ewes) were weaned at the normal 70 days of age. Of the 36 early weaned and control ewes, 33 (91.6 percent) and 24 (66.7 percent) mated with intervals (average number of days from lambing to first mating) of 58 and 64 days respectively. Of the ewes mating, 21 early weaned (58.3 percent) and 14 control (38.8 percent) ewes conceived to lamb the following fall with average spring lambing to conception intervals (average number of days from lambing to conception) of 58 and 65 days respectively. Early weaned and control ewes produced an average of 1.52 and 1.64 lambs per ewe lambing.

These results suggest that early weaning of lambs increases the percentages of ewes mating and conceiving following lambing in the spring and also decreases the interval from lambing to conception. However, there were not enough ewes involved to show conclusively how much improvement one might expect and the trial will be repeated.

Introduction

Currently sheepmen in Oklahoma are searching for some type of management system whereby they can increase lamb production without greatly increasing outlays of land and capital. One method by which this might be accomplished involves increasing the number of times a ewe lambs each year. In 1963 a program was initiated at the Fort Reno Livestock Research Station, El Reno, Oklahoma, to evaluate the problems associated with a twice-a-year lambing system. A ewe successfully performing on a twice-yearly lambing schedule would carry lambs for 294 days out of a year; thus within the remaining 71 days, she would lamb, rebreed and conceive twice.

Results from this twice-yearly lambing study, reported in 1969, indicated that the intervals from lambing to conception in the spring and

*In cooperation with the Agricultural Research Service, Animal Science Research Division, USDA.

fall seasons were 66 and 44 days respectively. Also, 71 percent of the ewes lambing in the fall rebred and conceived while only 23 percent of the spring lambing ewes rebred and conceived. Thus, a large percentage of the ewes in both the spring and fall did not conceive soon enough after lambing to maintain a successful twice-yearly lambing program. Also, a much greater percentage of the total lambs produced were born in the spring.

In an effort to discover ways to reduce the interval from lambing to conception and also to increase the number of ewes conceiving in the spring, an early weaning trial was conducted in the spring of 1970.

Materials and Methods

In the fall of 1969, the experimental ewes at the Fort Reno Livestock Research Station were exposed to fertile rams from October 20 to November 10. Thus lambing in the spring of 1970 was from March 15 through April 5 during which time 72 ewes (12 Dorset; 28 Dorset-Rambouillet Crossbred; 32 Rambouillet) gave birth to 45 sets of twins, 2 sets of triplets and 25 singles. These 72 ewes were alloted into two groups as they lambed with approximately half of each type (breed or breed cross) of ewe and half of each type of lambing (triplets; twins; singles) represented in each group. The lambs of 36 of the ewes were weaned at 30 days of age (early weaned ewes) while the remaining 36 ewes (control ewes) suckled their lambs until the normal weaning age of 70 days.

As lambs were weaned at 30 days of age, the ewes were exposed to fertile rams as were control ewes as their lambs reached 30 days of age. Thus breeding began when the oldest lamb reached 30 days of age (April 15, 1970) and continued through June 15. Therefore, some ewes were exposed to fertile rams for as long as 60 days while later lambing ewes were exposed for a shorter period of time. However, the latest lambing ewes (giving birth on April 5) were exposed to fertile rams for at least 40 days. This system allowed a ewe that lambed March 15 a period of 90 days to show estrus and a ewe that lambed April 5 had 70 days in which to show estrus before breeding ended on June 15. Mating records were obtained by use of sire marking harnesses and visual observation. All ewes were allowed to go full term and lambing began September 30, 1970. Thus, both mating and conception records were available.

A creep area was available to all lambs within ten days after their birth. The creep feed consisted of five percent molasses, 55 percent cracked milo, ten percent soybean meal and 30 percent ground alfalfa hay. All lambs to be early weaned, upon reaching 30 days of age, were removed from the vicinity of their dams and placed in a small pen (20 feet by 40 feet) at a lamb feeding barn with only the creep feed and water available

to them. After approximately 20 days, the lambs were allowed out of the small pen and until marketed, had access to a large dry lot at the feeding barn. As the lambs of the control ewes were weaned at 70 days of age, they too were moved to the lamb feeding area, but were contained in a different dry lot than the early weaned lambs in order to keep accurate feed consumption records for both groups.

In an effort to control internal parasite infestation, none of the lambs were ever allowed out of the dry lot. When the youngest lambs were about 12 weeks old, the soybean meal was removed from the creep ration and replaced with ground alfalfa. When the oldest lamb reached 30 days of age, a biweekly weighing schedule was initiated and continued until all lambs were marketed at approximately 93 pounds.

Results and Discussion

Even though the number of ewes involved in this trial was somewhat limited, certain trends are evident. This discussion will be limited to comparisons of mating and reproductive performances of early weaned and control ewes as well as a summary of lamb performance.

Table 1 presents a summary of the post-lambing mating performance of all ewes under this program. Thirty-three early weaned ewes (91.6 percent) mated with an average interval of 58 days from lambing to first post-lambing estrus. Only 24 control ewes (66.7 percent) mated during the same period with an average interval of 64 days from lambing to first post-lambing estrus. The average first post-lambing estrus for early weaned and control ewes was May 24 and May 30 respectively. Thus, a greater percentage (91.6 vs 66.7) of the early weaned ewes mated after lambing, and they also mated six days earlier than the control ewes.

Table 2 presents a summary of the subsequent fall lambing performance of early weaned and control ewes. Of the 36 early weaned ewes exposed to fertile rams in the spring, 21 or 58.3 percent conceived and

Table 1. Mating Performance of Early Weaned and Control Ewes Following Spring Lambing.

	Early Weaned Ewes	Control Ewes
No. of ewes[1]	36	36
Avg. Spr. lambing date	March 27	March 27
No. ewes mating	33	24
% ewes mating	91.6	66.7
Avg. 1st mating date	May 24	May 30
Avg. int. lambing to first mating[2]	58	64

[1] Number of ewes available.
[2] For those ewes that showed estrus.

Table 2. Summary of Reproductive Performance of Early Weaned and Control Ewes Following Spring Lambing.

	Early Weaned	Control
No. of ewes[1]	36	24
No. of ewes mating	33	14
No. of ewes conceiving	21	38.8
% lamb, mate, conc. of ewes available	58.3	May 31
Avg. conc. date	May 24	64
Avg. int. lamb to conc.	58	1.64
Lambing rate[2]	1.52	37.4
% ewes conc. to 1st mating	48.4	58.3
% ewes conc. of ewes that mated	63.6	36

[1] Number of ewes available.
[2] Based on ewes that lambed.

lambed the following fall. However, only 14 of the 36 available control ewes (38.8 percent) conceived during the spring breeding season to lamb the following fall. With respect to the number of ewes conceiving of ewes mating, 33 early weaned ewes mated with 21, or 63.6 percent, conceiving while only 14 of the 24 (58.3 percent) control ewes mating actually conceived. The average intervals from spring lambing to conception were 58 and 64 days respectively for early weaned and control ewes. Thus a greater percentage (58.3 vs 38.8) of the early weaned ewes conceived in a shorter period of time (58 vs 64 days) than the control ewes.

Lambing rates (average number of lambs born per ewe lambing) in the fall were similar for both groups of ewes with early weaned and control ewes producing an average of 1.52 and 1.64 lambs respectively.

The performance of the early weaned lambs and lambs of the control ewes is summarized in Table 3. The early weaned lambs gained at a somewhat slower rate (0.55 vs 0.63 pounds per day) from birth to 70-days than lambs of the control ewes. However, gains from 70-days to market were more comparable (0.52 vs 0.57 pounds per day) for the early weaned lambs and the lambs weaned at 70 days of age. Thus, the lambs from the control ewes were heavier at 70 days of age (56.9 vs 48.4 pounds) and reached market weight (97.2 vs 92.8 pounds) nine days earlier (147 vs 156 days) than the early weaned lambs.

The results of this study indicated that early weaning of lambs increased the percentage of ewes mating and conceiving following lambing in the spring and also suggested a decreased interval from lambing to conception. However, this interval was not decreased enough by early weaning to assure a successful twice-yearly lambing program. But since a greater percentage (58.3 vs 38.8 percent) of the early weaned ewes did conceive following lambing in the spring and gave birth to lambs the fol-

Table 3. Performance of Lambs Weaned at 30 Days of Age and Lambs Weaned at 70 Days of Age.

	Weaned at 30 days of age	Weaned at 70 days of age
ADG birth to 70-days	0.55	0.63
70-day weight	48.4	56.9
ADG 70-days to mkt.	0.52	0.57
Avg. mkt. age	156	147
Avg. mkt. wt.	92.8	97.2

lowing fall, early weaning could prove useful in some situations. If a sheepman wished to convert a group of spring lambing ewes to fall lambing schedule without sacrificing a complete lambing, early weaning could aid in this conversion.

Adaptation of Sheep to Biuret as a Nitrogen Source When Fed Low Quality Roughages

R. R. Johnson

Story in Brief

Rumen fistulated lambs were utilized to study the adaptation of rumen microflora to biuret as a source of nitrogen. The lambs were fed a low quality bermudagrass hay plus supplements containing either (1) cottonseed meal, (2) biuret, (3) biuret + cornmeal or (4) urea + cottonseed meal. There was little apparent effect of the nitrogen supplements on digestibility of dry matter, organic matter or fiber. Nitrogen retention data was highly variable.

When rumen contents from the lambs were utilized as inoculum for *in vitro* cellulose digestion studies, there appeared to be no adaptation

to the biuret as a source of nitrogen since after feeding biuret for over 80 days, the inoculum still would not digest cellulose when biuret served as the only *in vitro* source of nitrogen. On the other hand, when biuret disappearance and ammonia appearance data were considered during the conduct of the trial, there was definite evidence for adaptation of the microflóra to biuret. Ammonia appearance *in vivo* from biuret was considerably more rapid on day 87 than on day 4 of the supplemental feeding period.

The *in vitro* biuretolytic activity of the inoculum from non-biuret fed animals was negligible throughout the entire study. Release of ammonia from biuret was obvious at day 42 when the inoculum from biuret fed animals was tested *in vitro* and was even greater on day 87. Disappearance of biuret *in vitro* was slightly greater for the inoculum from biuret fed animals at day 14 and was markedly improved in these inocula in later periods of the study. The significance of these observations are presently being studied in additional experiments.

Introduction

Previous work in Oklahoma and elsewhere has clearly demonstrated the need for supplemental protein for ruminant animals during the winter grazing periods. This is true whether grazing native grasses or introduced species such as bermudagrass. In fact, this protein supplementation constitutes, in many cases, the major portion of the feed cost for grazing animals. It is of interest, therefore, to continue to search for lower cost supplements which will be acceptable and high in nutritive value.

Non-protein nitrogen has been utilized very successfully in protein supplements for cattle and sheep being fed in the feedlot. The major source of non-protein nitrogen in these supplements has been urea. The relatively low cost of urea in recent years has made the substitution of natural protein by urea a very economical practice.

Numerous experiments have also been carried out in attempts to utilize urea in range supplements with somewhat less success. Urea is very quickly hydrolyzed in the rumen to the ammonia form of nitrogen. This form of nitrogen can be rapidly absorbed from the rumen and may be excreted or, under some circumstances, may cause an ammonia toxicity in the animal. This condition is very unlikely in animals on high concentrate rations since the ammonia is rapidly utilized by the microorganisms digesting the highly available forms of carbohydrates.

When dry roughages, such as those used in Oklahoma winter grazing, are consumed there is very little of the highly available form of carbohydrate. As a consequence, much greater chance for nitrogen loss and for possible toxicity exist. Therefore, searches have been underway

for other forms of nitrogen which are less toxic and still available for utilization by the rumen microorganisms. One form which has been studied recently is biuret. Biuret is a non-protein nitrogen source similar chemically to urea but generally hydrolyzed much slower in the rumen. Previous workers have shown that a considerable adaptation period is necessary prior to the development of the ability for ruminants to utilize biuret efficiently.

The project being reported here was initiated in early 1970 to study the adaptation of ruminants to biuret when different forms of roughages and concentrates were being fed. The results of the first years studies are reported here.

Materials and Methods

Twelve lambs were fitted with rumen cannulas in the winter of 1970. Bermudagrass hay harvested in February from an ungrazed bermudagrass plot was utilized as base feed throughout the entire study. Although intended to be a very low quality roughage, the crude protein content of this bermudagrass hay was approximately 9 percent on a dry matter basis. The twelve lambs were divided into four groups and fed the rations shown in Table 1. All lambs received 450 gm of chopped bermudagrass hay plus the supplements as indicated daily. Since the biuret supplement was very unpalatable, it was poured into the rumen through the cannula each morning prior to feeding. During the course of the experiment, one animal on supplement 2 died.

Table 1. Composition of Rations and Daily Feed Allowance for Biuret Trial 1.

	Daily Feed Allowances (Grams)			
	Ration 1	Ration 2	Ration 3	Ration 4
Low Quality Bermuda grass hay	450	450	450	450
Supplement 1	168	---	---	---
Supplement 2	---	45	---	---
Supplement 3	---	---	195	---
Supplement 4	---	---	---	179
Supplement Composition	1 %	2 %	3 %	4 %
Cottonseed meal	89.3	---	---	41.9
Ground corn	---	---	77.0	41.9
Biuret	---	60.0	13.8	---
Urea, 281	---	---	---	6.1
Dicalcium phosphate	3.6	13.3	3.1	3.3
Limestone	3.6	13.3	3.1	3.3
Trace mineralized salt	3.6	13.3	3.1	3.3

Prior to the initiation of supplemental feeding all animals were placed on bermudagrass hay plus cottonseed meal supplement for 14 days. During this period of time, one digestion trial was conducted consisting of a 7-day collection period in which total feces and urine collections were made in addition to accurate observations of feed consumption. After the initiation of supplementation, digestion trials were conducted at three different periods during the course of the 87-day feeding period.

On days 4 and 87 of the supplemental feeding period, rumen samples were removed from each animal at 0, 1, 2, 4 and 8 hours after feeding for ammonia and biuret analyses. On days 4, 14, 21, 42, 66 and 84 of the supplemental feeding period, the ability of the rumen microorganisms to release ammonia from biuret was measured *in vitro* in the laboratory. This was accomplished by taking a sample of the rumen contents from each animal and mixing it with a known quantity of biuret and incubating the mixture at 39°C for 24 hours. Samples were removed from flasks at 0, 8 and 24 hours to determine the disappearance of the biuret and the appearance of ammonia.

The ability of the rumen microorganisms to utilize biuret as a source of nitrogen for the digestion of cellulose was measured using an *in vitro* system in which the rumen microorganisms taken from each animal were used to innoculate flasks containing purified cellulose and all of the nutrients required for their growth except for nitrogen. Cellulose digestion was then measured in flasks which contained either (1) no nitrogen source, (2) urea, which served as a positive control, or (3) biuret.

Results and Discussion

Apparent Digestibilities. The coefficients of digestibility of dry matter, organic matter, acid detergent fiber and kjeldahl nitrogen as well as nitrogen balance are shown in Table 2. Statistical analyses of these data have not been conducted as yet. It would appear that the digestibilities of ration 2, the biuret supplemented ration, are definitely lower than the digestibilities for the other three rations. The most likely explanation for this result, however, is not due to the nitrogen supplement itself but to the fact that the three rations with the highest digestibility contained either cornmeal, cottonseed meal or both. Cornmeal and cottonseed meal both have high digestibilities, whereas ration 2 did not contain either of these high energy supplements.

The nitrogen digestibility of rations 2, 3 and 4 appear to be higher than that for ration 1. Again this explanation is very likely due to the fact that the latter three rations contain non-protein nitrogen which

Table 2. Apparent Digestibilities and N-balance For Biuret Supplemented Rations (Trial 1).

Measurement	Period[1]	Ration 1	Ration 2	Ration 3	Ration 4
Dry Matter, %	1	47.2	58.5	47.8	52.2
	2	54.2	46.5	51.8	55.6
	3	52.8	45.8	54.3	52.8
	4	50.5	46.7	55.1	51.8
	$\bar{x}$[2]	52.5	46.3	53.7	53.4
Organic Matter, %	1	49.4	60.4	50.2	53.9
	2	57.1	49.3	54.9	58.0
	3	54.1	47.5	56.0	54.8
	4	52.3	48.0	56.9	53.9
	$\bar{x}$[2]	54.5	48.3	55.9	55.6
Acid Detergent fiber, %	1	40.2	46.5	39.7	40.4
	2	48.1	38.8	36.7	43.2
	3	44.0	36.7	35.5	37.9
	4	44.7	38.0	39.5	40.7
	$\bar{x}$[2]	45.6	37.8	37.2	40.6
Nitrogen, %	1	66.3	70.1	62.3	68.4
	2	66.5	73.8	68.6	73.4
	3	69.6	76.7	76.2	72.1
	4	68.4	78.0	78.1	74.5
	$\bar{x}$[2]	68.2	76.2	74.3	73.3
N-balance, gm/day	1	3.66	2.52	3.34	3.02
	2	4.26	2.06	3.38	2.70
	3	3.07	1.61	3.81	2.13
	4	2.89	7.94	1.28	3.35
	$\bar{x}$[2]	3.41	3.87	2.82	2.73

[1] Period 1 (Day −19 to −12), Period 2 (Day 6 to 11), Period 3 (Day 24 to 30), Period 4 (Day 74 to 81) with Day 1 being the start of supplemental feeding.
[2] Averages of last 3 periods.

almost invariably increases the apparent digestibility of nitrogen. These forms of nitrogen are absorbed and even though they may be excreted for the large part they appear as digested nitrogen. The nitrogen balance data is quite inconsistent and does not show any trends which are useful. When one compares periods 2, 3 and 4 within these data, there would appear to be a slight decrease in dry matter and organic matter digestibilities during the conduct of the trial, at least for rations 1 and 4. No particular explanation can be offered for this at the moment.

In contrast, nitrogen digestibility appeared to increase during the conduct of the trial for rations 2 and 3, the biuret supplemented ration, whereas there was no significant change for rations 1 and 4. This result is not likely due to increased absorption of the nitrogen since the biuret form of nitrogen would presumably be absorbable at any period of the trial.

In vitro cellulose digestibility data. In vitro cellulose digestibility by the rumen microorganisms from two of the three animals on each treatment was determined three days prior to the commencement of supplementation and on days 12, 19, 39 and 80 after the commencement of supplementation. The data from these determinations are shown in Table 3. In all cases, the tubes containing urea as the source of nitrogen had cellulose digestibilities which were considerably higher than the control tube, the one without nitrogen. On the other hand, those tubes containing biuret rarely had cellulose digestibilities which were any higher than the control tubes suggesting that the biuret nitrogen could not be utilized for cellulose digestion by these microorganisms. This was generally true for all of the animals whether they had been adapted to biuret or not.

On days 39 and 80 there appeared to be slightly higher cellulose digestibility in the tubes containing biuret nitrogen as compared to the tubes containing no source of nitrogen. These slight apparent increases in no way come close to the digestibilities supported by urea as a source

Table 3. Utilization of Biuret and Urea Nitrogen to Support In Vitro Cellulose digestion[1] by Inoculum from Biuret Adapted and Non-Adapted Lambs.

Ration	N-Source[2]	Trial Day (Percent)				
		−3	12	19	39	80[3]
1	O	19.4	21.0	23.8	18.7	19.7
	U	44.7	46.4	46.1	42.0	---
	B	23.2	21.1	23.2	18.9	20.0
2	O	23.0	12.9	26.1	20.2	22.6
	U	41.3	29.2	46.2	42.6	---
	B	27.7	13.9	25.9	22.6	27.4
3	O	18.5	14.4	15.1	16.5	19.0
	U	37.4	37.8	47.8	38.3	---
	B	18.6	14.1	14.7	24.3	25.3
4	O	23.0	22.0	22.4	13.3	21.9
	U	43.9	55.4	53.1	40.4	
	B	20.9	21.7	21.6	12.4	21.8

[1] Data reported at % digestion of a change of 0.5 gm cellulose in a 30 ml volume *in vitro* tube. Values are averages of two lambs.
[2] O=No N-Source, U=urea, B=Biuret.
[3] Urea was omitted inadvertantly. Biuret-control comparison is valid, however.

of nitrogen. Thus, biuret was considerably less than optimal as a nitrogen source. In this case, then, there appeared to be no marked evidence of adaptation of the cellulose digesting microorganisms to biuret as a nitrogen source.

In vivo rumen ammonia release from biuret. Figure 1 shows the results of the ammonia analyses on rumen samples taken from the supplemented animal on days 4 and day 87 after the initiation of supplemental feeding. The curves for rations 1 and 4 represent rather typical curves in which natural protein (ration 1) or urea (ration 4) are utilized as nitrogen sources. With the natural protein, there is a rather slow release of the ammonia and usually a falling off of the rumen ammonia level due to utilization by the microorganisms.

With the urea supplemented rations, there is always a very rapid rise in rumen ammonia due to the hydrolysis of the urea and a subsequent gradual decrease due to both absorption and excretion as well as utilization by the rumen microorganisms. There is no particular difference between the curves for days 4 and 87 for the cottonseed meal supplement. The release of the ammonia from urea and cottonseed meal combinations in ration 4 was very rapid on both days 4 and 87, but appeared to fall off more rapidly on day 4 than 87.

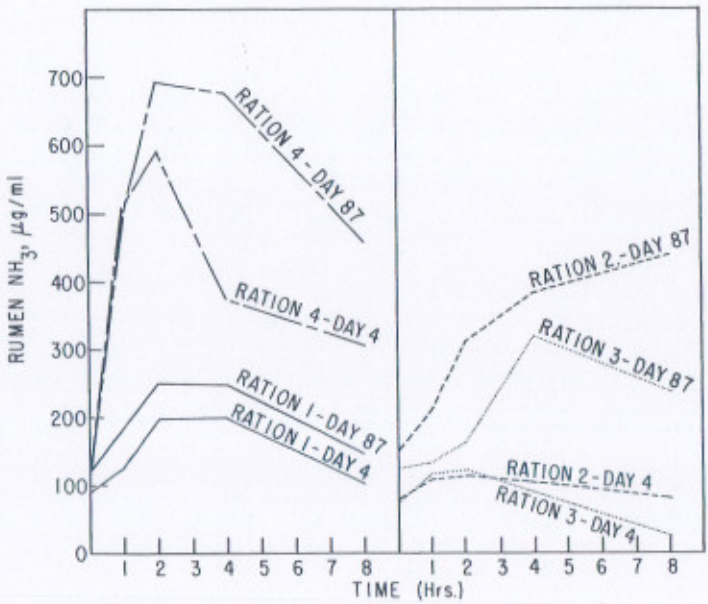

Figure 1. In Vivo NH_3 Release from N-Supplements.

The data for rations 2 and 3 are much more striking and revealing. In both cases, there is very little ammonia release on day 4 suggesting the biuret was not being hydrolyzed or at least was not being hydrolyzed fast enough for ammonia to accumulate. On day 87, however, with both biuret supplemented rations, there was an obvious increase in ammonia following feeding. Thus, these data show clearly that there had been an adaptation to biuret during this lengthy period and that on day 87 there was obviously some hydrolysis of the biuret to ammonia, which then suggests that utilization could occur.

Biuretolytic activity in vitro. The disappearance of biuret and the appearance of ammonia during the *in vitro* ammonia release tests would

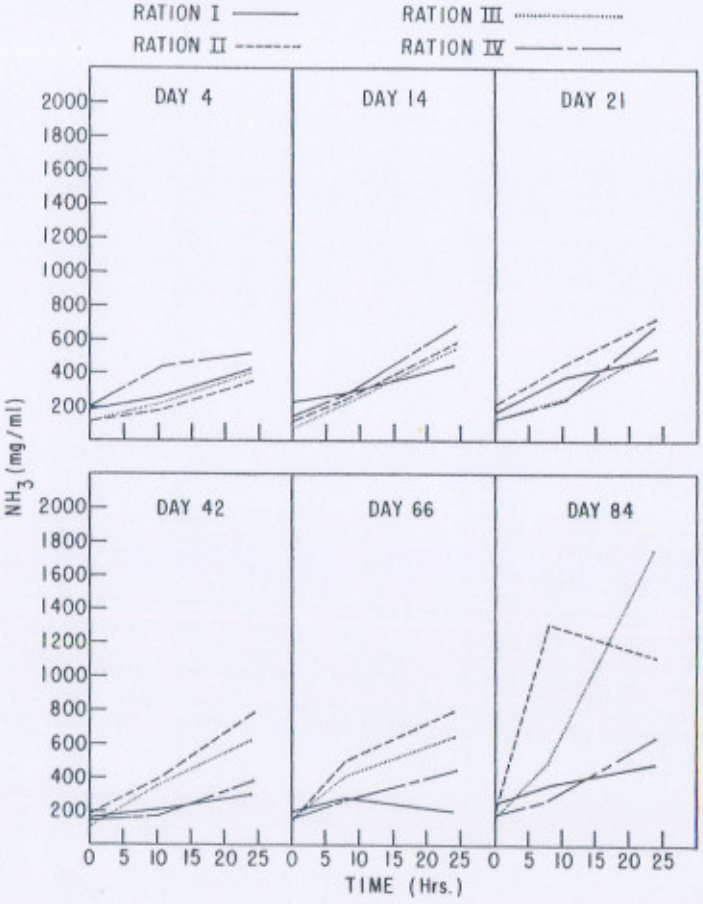

Figure 2. NH_3 Release From Biuret in Vitro.

be an indication of biuretolytic activity by the rumen microorganisms. Figures 2 and 3 show the appearance of ammonia and the disappearance of biuret, respectively, as the feeding period progressed. In Figure 2, it can be seen that the ammonia appearance curves do not differ markedly until the measurement taken on day 42. At that time, it would appear that the inocula taken from biuret fed animals were beginning to release more ammonia from biuret than that taken from animals that had not been fed biuret. On day 66, the results are rather similar to day 42. On day 84, however, a considerable divergence in lines between those

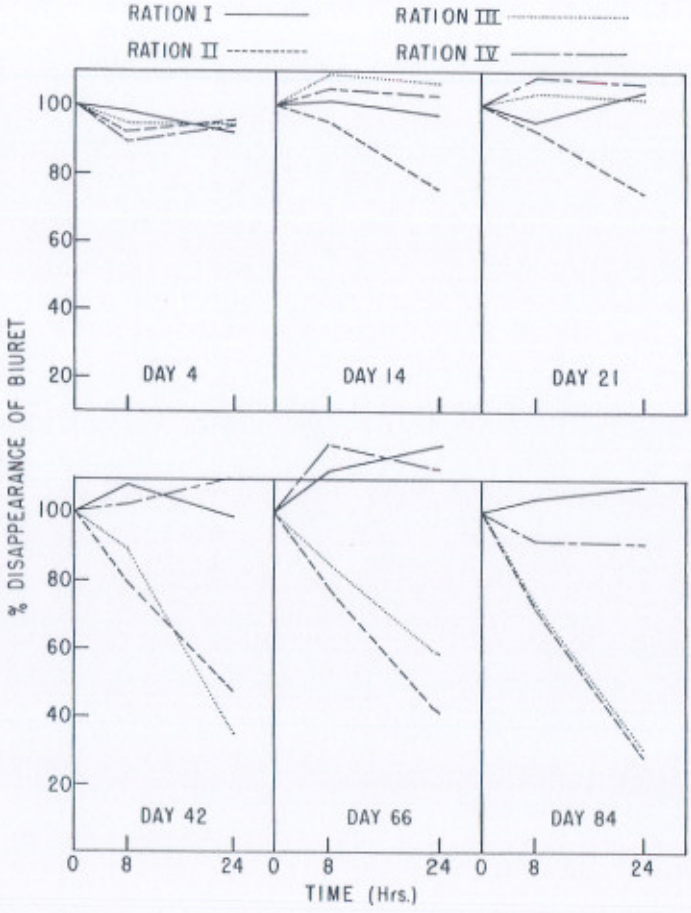

Figure 3. Biuret Disappearance in Vitro.

fed or not fed biuret appeared. There is a very obvious increase in ammonia appearance from the added biuret throughout the 24 hours with the inoculum from animals fed ration 3 and very rapid release up to 8 hours with the inoculum from ration 2, with an apparent leveling off at that point. Thus, these data also demonstrate adaptation of the rumen microorganisms to biuret.

Figure 3 shows the biuret disappearance at these same periods. These data suggest that biuretolytic activity started to a small degree by day 14 with ration 2 but was not markedly obvious until day 42 at which point inoculum from both rations 2 and 3 hydrolyzed significant amounts of biuret. In fact, on the basis of this evidence little additional biuretolytic activity could be found on day 84. Thus, although adaptation to biuret was indicated by both critera, biuret disappearance was evident before increased ammonia appearance could be observed.

Conclusions

It is evident from these results that there was definitely an adaptation of the rumen microflora to biuret as a source of non-protein nitrogen. The adaptation was not obvious in the digestion trial data, however. On the other hand, in those studies designed to measure the ability of the microflora to degrade the biuret to ammonia, there was very positive evidence of this adaptation. Although the biuret disappearance measurements suggested that adaptation might begin as early as 14 days, the ammonia appearance data would suggest that major adaptation took 42 days or longer.

This poses two interesting questions. First, is the possible lengthy adaptation of 42 days or longer impractical as far as useful feeding systems in the field. Secondly, even after adaptation, is the rate of release of ammonia rapid enough to support proper rumen digestion. The answers to these questions await further studies which are presently underway. This type of an experiment is presently being conducted again using a lower quality native grass hay and further studies are planned to evaluate the usefulness of this source of non-protein nitrogen.

Complete Rations for Dairy Cows

L. J. Bush

Story in Brief

There is considerable interest in using complete rations for dairy cows because of the possibilities of reduced labor cost and availability of a typical roughage sources. Materials used in some areas to substitute for hay or silage of conventional rations include citrus pulp, cottonseed hulls, waste paper and sawdust. Since some of these are not universally available and are of limited nutritional value, it was of interest to explore other possibilities for replacing conventional sources of roughage in dairy rations.

Four separate trials were conducted to examine the feasibility of using inert polyethylene (corrugated pellets approximately 10 x 7 x 5 mm in size) as a partial or complete substitute for natural roughage in rations for dairy cows. Measurement criteria were feed intake, rumen fermentation pattern, milk yield and composition, and incidence of digestive disorders. Factors considered in the different trials included the amount of natural roughage (hay) in the ration, procedure for introduction of the polyethylene pellets, and stage in lactation cycle at which the polyethylene was fed.

Under the conditions used in these trials, polyethylene pellets did not substitute effectively for natural roughage in rations for lactating cows. Feed intake was not maintained at a satisfactory level and the rumen fermentation pattern was not commensurate with desired milk fat percentage. There was a progressive decline in the amount of polyethylene retained in the rumen of fistulated animals fed a ration with 10 percent hay so that only 15-19 percent of that fed remained at the end of 4 weeks.

Introduction

One of the functions of roughage in a dairy ration is to contribute bulk or a "roughness factor" to the rumen ingesta which helps maintain

Supported in part by a grant-in-aid from Farmland Industries, Inc.

the health of the ruminal tissue. This research explored the possibility of using a small amount of inert polyethylene material to serve this function. In particular, it was of interest to consider using material which might stay in the rumen for an extended period, instead of feeding some material on a continuous basis. The criteria by which the effectiveness of inert polyethylene as a roughage substitute was evaluated were as follows:

a) acceptability of the required amount of polyethylene material by the cows.
b) feed intake of cows over an extended period.
c) milk yield and composition.
d) rumen fermentation pattern.
e) incidence of digestive disorders.

Materials and Methods

Trials were conducted to investigate the effects of using polyethylene material under different conditions as regards extent of roughage replacement, procedure for introducing the material, and stage of lactation cycle at which cows were started on experiment.

Trial 1

Eighteen lactating cows were used in an 8-week trial to evaluate the effects of different amounts of polyethylene[1] and alfalfa hay in the ration. A 3 X 3 factorial arrangement of treatments was used. Levels of polyethylene with time of administration were: a) None, b) 4 lb. fed at start of trial, and c) 4 lb. fed at start of trial plus a daily allotment equal to 1 percent of the grain allowance. Levels of hay as a percent of total ration (air-dry basis) were: a) None, b) 10 percent, and c) 20 percent.

At the start of the trial, 4 lb. of polyethylene material (10 X 7 X 5 mm pellets) were fed to each animal, except those in the zero level group, in equal portions at each feeding over a 4-day period. Essentially all of this amount of polyethylene was consumed. The percentage of hay in the ration was reduced simultaneously by equal increments from 50 percent to the designated level. Grain intake was increased as necessary to maintain constant energy intake.

The grain ration consisted of crimped corn 33.75 percent, crimped sorghum grain 20 percent, wheat bran 15 percent, crimped barley 11 percent, soybean oil meal (44 percent) 10 percent, liquid molasses 7 percent, calcium carbonate 1.25 percent; trace mineral salt 1 percent, calcium phosphate 1 percent.

The animals in the group designated to receive additional polyethylene on a continuous basis were fed an amount equal to 1 percent of the grain ration at each feeding following the initial 4-day period. Although

[1] One-half size corrugated polyethylene pellets (RUFF-TABS) supplied by Farmland Industries, Inc.

the cows varied in their tendency to sort out and refuse the material, it was estimated that three-fourths or more of the daily 1 percent allotment was consumed.

Trial 2

Eighteen lactating cows were used in this trial to evaluate the effects of feeding polyethylene under conditions where all hay was withdrawn from the ration before polyethylene was introduced. The ration treatments were a) Grain + hay (50:50), b) All grain (no polyethylene), and c) All grain + 6 lb. polyethylene. Hay was withdrawn from the ration of cows assigned to the all-grain rations over a 10-day period, with grain increased sufficiently to maintain constant net energy intake. Six pounds of polyethylene were fed to cows in group "c" in equal increments over a 12-day period starting on the second day the cows were on an all grain ration.

Trial 3

All conditions of this trial were essentially the same as those in the previous trial, except that the 12 cows involved were started on the experimental rations prior to calving.

Trial 4

Three fistulated non-lactating animals were used to obtain information regarding the retention of polyethylene in the rumen. The animals were assigned to treatments in a 3 X 3 Latin square design with three 4- week periods and three levels of polyethylene as used in Trial 1. Alfalfa hay was fed at a 10 percent level. During the pre-trial period and each 2-week interval between periods, a 50:50 hay to grain ration was fed. Introduction of the polyethylene was accomplished in the manner described in Trial 1, except that material refused during the initial 4-day period was separated from the grain and introduced through the rumen fistula.

At weekly intervals rumen ingesta samples were collected, and at the end of each 4-week period the rumen-reticulum was completely emptied to determine the retention pattern of the polyethylene in the rumen.

Results and Discussion

Trial 1

In general, feed intake by the different groups was a reflection of feed allowances, based on net energy requirements for maintenance and production. A general decline in intake during the first 4 weeks of the trial was attributed to numerous incidents of temporary off-feed conditions where individual cows refused a large percentage of their feed.

There was very little difference in the number of incidents of feed refusals among groups fed different levels of hay; however, larger amounts of feed were refused by the group fed no hay. Feeding of the polyethylene in the manner indicated in the previous section tended to reduce the incidence of feed refusals in this trial, at least to some extent. However, feed intake was not maintained in any of the groups at a satisfactory level for high milk production.

Neither level of hay nor level of polyethylene had a significant effect on milk yield, and there was not a significant interaction between the two factors. Average production by the group fed no hay declined more in relation to pre-trial production than that of the other groups (Table 1), presumably because of a greater decrease in feed intake as noted above.

The cows receiving no hay exhibited a substantial decrease in milk fat percentage, whereas a smaller decline was evident in the groups fed either 10 or 20 percent hay. Average fat percentages for different polyethylene groups was 3.3, 3.4 and 3.1 for the zero, 4 lb. initial, and 4 lb. plus 1 percent daily groups, respectively. Thus, feeding of polyethylene under the conditions of this trial was not an effective means of maintaining desirable fat percentage in milk of cows fed high grain rations.

Table 1. Average Daily Milk Yield and Composition

Treatment group	Pre-trial		1-4 weeks			5-8 weeks		
	Milk	Fat	Milk	Fat	T.S.	Milk	Fat	T.S.
	(kg)	(%)	(kg)	(%)	(%)	(kg)	(%)	(%)
No hay								
No polyethylene	23.1	3.4	20.5	3.0	11.65	17.1	3.1	11.79
1.8 kg	22.6	3.6	19.2	3.1	11.81	16.4	2.9	11.48
1.8 kg + 1% daily	26.2	3.2	23.1	2.7	11.75	21.1	2.9	11.85
Average	24.0	3.40	20.9	2.91	11.74	18.2	2.97	11.72
10% hay								
No polyethylene	23.4	3.6	21.7	3.3	12.30	20.6	3.6	12.52
1.8 kg	23.5	4.2	22.3	3.7	12.74	18.8	3.5	12.32
1.8 kg + 1% daily	20.4	3.4	19.6	3.5	12.50	17.8	3.2	12.08
Average	22.4	3.73	21.1	3.47	12.51	19.1	3.43	12.31
20% hay								
No polyethylene	21.8	3.7	21.1	3.7	12.49	18.1	3.8	12.83
1.8 kg	23.2	3.5	20.6	3.5	12.57	19.1	3.3	12.40
1.8 kg + 1% daily	21.1	3.7	19.4	3.0	11.50	17.3	3.0	11.35
Average	22.0	3.63	20.4	3.40	12.19	18.2	3.33	12.19

Molar percentages of ruminal volatile fatty acids (VFA) during the pre-trial period were typical of values expected for cows consuming rations with a 50:50 ratio of grain to hay. Removal of all or part of the hay resulted in a lower percentage of acetic acid and a correspondingly higher percentage of propionic acid in the rumen fluid, as illustrated by acetic/propionic ratios during the second week of the experiment (Figure 1). The feeding of polyethylene had no consistent effect on the proportion of VFA in the rumen, Thus, the polyethylene material did not substitute effectively for roughage in terms of maintaining a typical fermentation pattern in the rumen.

Trial 2

Average production of the group of cows fed 6 lb. each of polyethylene at the start of an 8-week comparison period was lower than that of either of the control groups (Table 2). During the week that polyethylene was introduced, feed intake by the cows fed the polyethylene dropped below that of the other group fed only grain. Complete recovery in grain

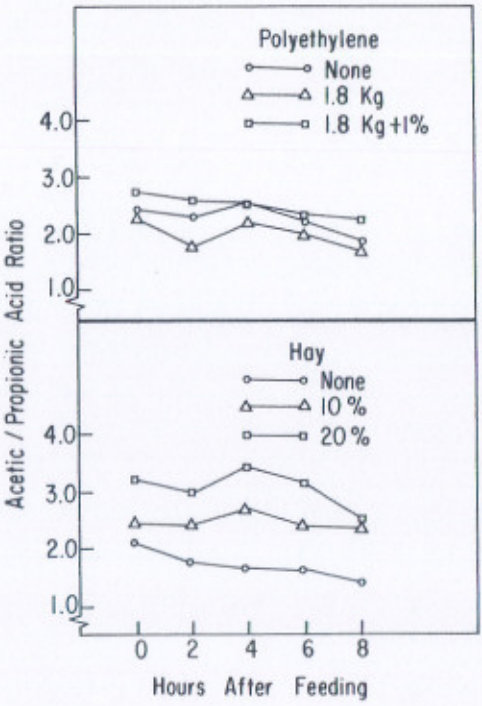

Figure 1. Acetic to propionic acid ratios in rumen fluid of cows during the second week of the experiment.

Table 2. Average Feed Intake and Milk Production of Cows—Trial 2.

Item	Ration treatment		
	Grain & hay (50:50)	Grain only	Grain + polyethylene
Air-dry feed intake, kg, day	19.3	14.4	11.4
Milk yield, kg/day	19.1	19.4	14.3
Fat, %	4.1	3.4	3.5
Total solids, %	13.0	12.4	12.3

intake did not occur, which may account for the lower production by this group.

The percentages of milk fat and total solids was lower in both groups fed all grain than in the control group fed both hay and grain (Table 2). Very little difference was evident until the third week on the experimental rations. From this point through the end of the trial, milk from the all-grain groups tested approximately 0.8 percent lower than that from the control group.

The amount of time spent ruminating was reduced markedly in both groups of cows fed an all-grain ration (Table 3). The polyethylene material did not promote increased rumination; however, a few cows were observed to regurgitate and discard the material. As in the previous trial, the observed pattern of rumen VFA production was not commensurate with maintenance of desired milk fat test.

Trial 3

In this trial cows were started on the experimental rations before calving. The results were similar to the previous trial, except that differences in fat test were less consistent (Table 4). Presumably, body stores were used for milk fat synthesis during the 12 weeks following calving with the result that distinct differences in fat test due to different rations did not become apparent. Nevertheless, it may be concluded that intro-

Table 3. Observations on Rumination During a Six-hour Period Two Weeks After Initiation of Trial 2.

Group	Hour after feeding						Total for 6 hr.
	2nd	3rd	4th	5th	6th	7th	
	Time spent ruminating (minutes)						
Hay + grain	0	10	17	17	21	20	85
Grain only	0	0	0	1/3	2/3	6	7
Grain + plastic	0	0	0	0	0	3	3

duction of the polyethylene material prior to calving did not alleviate all of the problems associated with feeding dairy cows an all-grain ration.

Trial 4

Under the conditions of this trial where the ration contained 10 percent roughage, there was a progressive decline in the amount of polyethylene retained in the rumen (Table 5). The material did not accumulate in the rumen of any of the three animals fed a 1 percent level daily. In fact, the polyethylene remaining in the rumen at the end of 4 weeks averaged 19 percent of the amount fed in animals given 4 lb. only at the start of the trial, as compared to 15 percent for those fed the same amount initially plus 1 percent daily.

Table 4. Average Feed Intake and Milk Production of Cows—Trial 3.

Item	Ration treatment		
	Grain + hay	Grain only	Grain + polyethylene
Air-dry feed intake, kg/day	18.9	11.5	9.9
Milk yield, kg/day	22.4	18.4	18.5
Fat, %	3.9	4.0	3.7
Total solids, %	13.01	12.75	12.01

Table 5. Retention of Polyethylene in Rumen of Fistulated Animals

Polyethylene treatment	Polyethylene in rumen at end of week:			Ingesta removed at end of 4-week period		
	2	3	4	Total DM	Polyethylene	
	(% of DM)			(kg)	(g)	(% of DM)
1.8 kg initially	19.6[1]	12.1	5.1	5.9	345	4.8
1.8 kg initially + 1%/day	23.9	10.9	6.9	4.0	281	8.4

[1] Each value is the average of three animals.

New Foods Through The Use Of Emulsifiers

J. B. Mickle

Story in Brief

Emulsifier research in the O.S.U. Foods Laboratory during the past 12 years has indirectly resulted in new types of butter, low-calorie spreads, milk powders and shortenings. A method was developed to classify and measure emulsifiers on the basis of their water solubility. Tables of data also were accumulated which can be used to predict the amount and solubility of emulsifiers needed for foods of various compositions.

Materials and Methods

An emulsifier is a compound which holds fat and water together, much like a staple holds together two pieces of paper. The use of these compounds results in a "stable emulsion", i.e., in milk drinks they keep the liquid homogenious and prevent the formation of cream layer. During the past twelve years the use of these compounds in various foods has been studied by the Foods Laboratory at Oklahoma State University. A great many new products have resulted from the use of emulsifiers and some of these are the direct result of O.S.U. research.

Only a small quantity of emulsifier is usually added to a food (0.1 percent—0.5 percent), but this small quantity will cause remarkable changes. It is responsible for the increased loaf volume of modern-day bread, and causes the bread to appear moist and retain that appearance longer. Emulsifiers have the same effect on cakes, i.e., they produce larger cakes which are more moist. The cakes also have a finer texture (1,2). Emulsifiers added to a powdered milk product will cause that powder to be more easily dispersed in water (3). This has resulted in a whole line of new products including "instant" milk, "instant breakfasts" and various powdered diet foods. Research at O.S.U. and other universities has shown that the addition of certain emulsifiers to butter will make the product more spreadable at refrigerator temperatures. Still other emulsifiers make it possible to produce low-calorie spreads containing only half

the fat of the normal product (4.) An emulsifier added to a cooking oil will prevent that oil from spattering when it's heated in the skillet. Emulsifiers added to milk or cream make that product readily whipable and have resulted in many new whipped creams and whipped topping products which are usually marketed in aerosol cans.

The unique characteristic of an emulsifier is the fact that it is soluble both in water and fat. This makes it possible for a portion of the molecule to dissolve in water while the other part of the same molecule is dissolved in fat. It's logical that to hold different amounts of fat and water together, different kinds of emulsifiers are needed, that is, emulsifiers with different water and fat solubilities. For example, in a food containing 80 percent fat and 20 percent water (a system similar to butter) an emulsifier is needed which is largely fat soluble, with only a small portion of the molecule being soluble in water. On the other hand, if the system to be stabilized contains approximately equal amounts of fat and water the emulsifier needs to be about 50 percent soluble in each substance (Figure 1).

Thus, different foods need emulsifiers with different solubilities and for optimum emulsifier performance one should know the amount of fat and water in the food which is to be emulsified. This ratio of water to fat in the product must then be matched with the water-fat solubility of the emulsifier molecule.

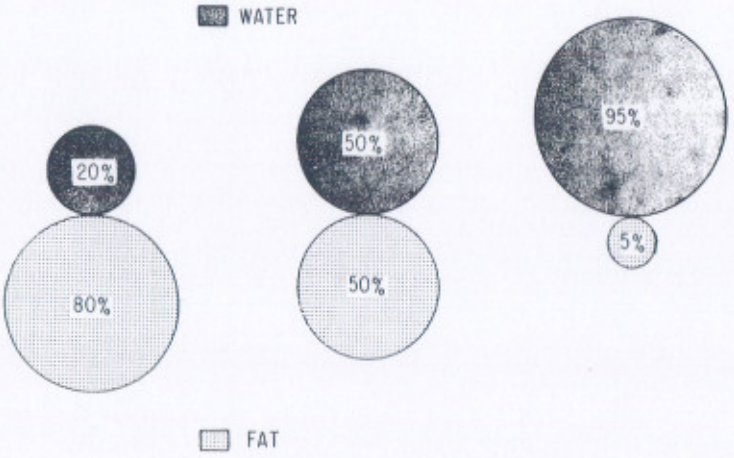

Figure 1. Graphical representation of emulsions containing 20, 50 and 95 percent water where circular areas represent the relative volumes of fat and water in each system.

Recent research at the O.S.U. Foods Laboratory has resulted in a technique which will measure the relative water-fat solubility of an emulsifier. This technique involves the use of a gas chromatograph and coating an inert support material (bleached firebrick for example) with the emulsifier to be tested, this coated support is packed into the column of a gas chromatograph then a test substance is injected—alcohols have been used. The speed with which the test substance passes through the emulsifier-coated support material is measured and this speed is proportional to the water-fat solubility ratio of the emulsifier coating (6).

The molecular configuration of an emulsifier will control its water-fat solubility ratio and this solubility ratio determines the effectiveness of the compound in a particular food. It's important to recognize that it is the water-fat solubility which controls an emulsifier's action but that more than one type of chemical formulation can result in the same solubility ratio. In work at Oklahoma State University (5, 6) a number of different emulsifiers with widely different molecular configurations were tested. The selection of these emulsifiers was so arranged that solubility ratios varied over a wide range. The results confirmed the fact that water-fat solubility ratio is the most important single factor governing an emulsifier's performance. This information tells one that if an emulsifier is needed that is 50 percent water soluble any molecular configuration with this solubility will do the job—i.e., a polysorbate, a diglyceride, a lactate or some other configuration.

Some authors claim that mixtures of two or more emulsifiers are more effective than a single one. However, the research to back up this statement often has been done without measuring the relative solubility of the emulsifier mixtures. A recent series of experiments at Oklahoma State University have shown that when two emulsifiers are combined the mixture acts as though it had a water solubility intermediate between the two components. For example, if an emulsifier which is 20 percent fat soluble is combined with an equal amount of an emulsifier that is 80 percent fat soluble, the solubility of the resulting mixture will be the average of the two components, or 50 percent (1, 2, 5, 6). What often happens, when two emulsifiers are combined is that the water-fat ratio of the product to be stabilized is more compatible with the solubility of the emulsifier mixture than with either of the individual components.

If only a limited number of emulsifiers are available to the manufacturer, mixing two of them is often the answer to an otherwise difficult emulsification problem. However, in today's market where a great many emulsifiers are available it usually is possible to find a single emulsifier with the proper solubility for any given food. When a single emulsifier can be found, it can be every bit as effective as would a combination of two or more.

Deciding Which Emulsifier to Use and How Much?

One should know the amount of water and fat in the product to be stabilized. These are simple measurements in the laboratory and any standard technique for moisture and fat will be adequate. In many cases though, the amount of fat and water can be calculated from the recipe of the product. An example of a cake recipe used in the O.S.U. laboratory is listed below (Table 1). In this recipe there are 48 grams of fat (as shortening) and 96 grams of water (in the skim milk). This is all that needs to be considered in this case since recent work at Oklahoma State University has indicated that the effect of ingredients other than fat and water on the emulsification of a cake is negligible. The addition of milk solids-not-fat for example, has an effect which is so small that for all practical purposes it can be disregarded. The same is true ofr flour and perhaps for other ingredients as well. In the recipe of Table 1, the amount of fat and water totals 144 grams and the fat percentage equals 48 ÷ 144 or 33 percent. The water:fat ratio then is 67:33.

With this information one consults a set of tables similar to those published from the O.S.U. laboratory in 1968 (6). To avoid confusion though, it is sometimes easier to use graphs derived from these tables. The data form a three-dimensional surface when three variables are considered and can be graphed that way (Figure 2). However, the same data can be shown as a family of curves (Figure 3) and this type of graph is often easier to use. Entering either Figure 2 or 3 at a point representing about 30 percent fat (or 70 percent water) one sees that the maximum emulsion stability results when an emulsifier is used which is 65 percent soluble in water. However, there is very little difference between this emulsifier and those which were 45 and 55 percent soluble in water. Since Figures 2 and 3 use data from systems containing only 1 percent emulsifier (as percent of the shortening), one must go back to the data

Table 1. Cake Recipe

Ingredient	Weight (grams)
Shortening	48
Sugar	120
Flour	96
Egg	32
Skim milk	105[1]
Baking powder	4
Salt	2
Flavoring & Color	1

[1] Contains 9 percent milk solids and 91 percent water (96 grams).

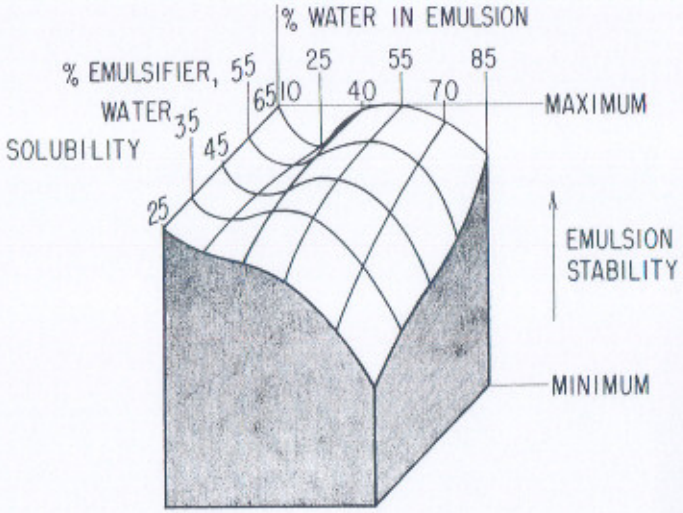

Figure 2. Three-dimensional graph showing the relative stability of fat-water emulsions containing percent emulsifier—calculated as a percentage of the fat.

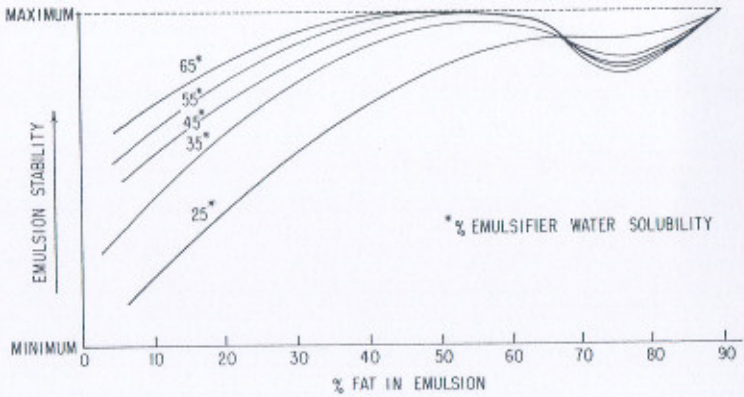

Figure 3. Two-dimensional graph showing the relative stability of fat-water emulsions containing 1 percent emulsifier—calculated as a percentage of the fat.

to complete the picture and determine how different amounts of emulsifier affect emulsion stability. From this graph (Figure 4) it also is apparent that when more than 1 percent emulsifier is used, the performance of emulsifiers with lower water solubilities (i.e., 45 and 55 percent) is almost equal to the performance of emulsifiers with water solubilities of 65 percent. This later was confirmed with actual cake baking trials.

Shortenings for Baked Goods

Many anhydrous fats can be used as shortenings in baked goods. However, these fats must be properly emulsified to be effective. An emulsifier with a water solubility of 50 percent will be satisfactory for a general-purpose shortening added to the fat at the rate of 1-2 percent (0.05-0.02 percent of the total product). However, it usually is preferable to "tailor-make" the shortening—that is, add emulsifiers of the proper water solubility to fit each individual product.

Anhydrous milk fat can be excellent shortening in properly emulsified. However, if butter is used as the source of this fat, one needs to remember that this product was designed as a table spread. It contains water and salt which the baker must take into account when calculating his recipe. In addition, the emulsifier in this product (lecithin) has a water solubility of approximately 80 percent, whch is too high for most

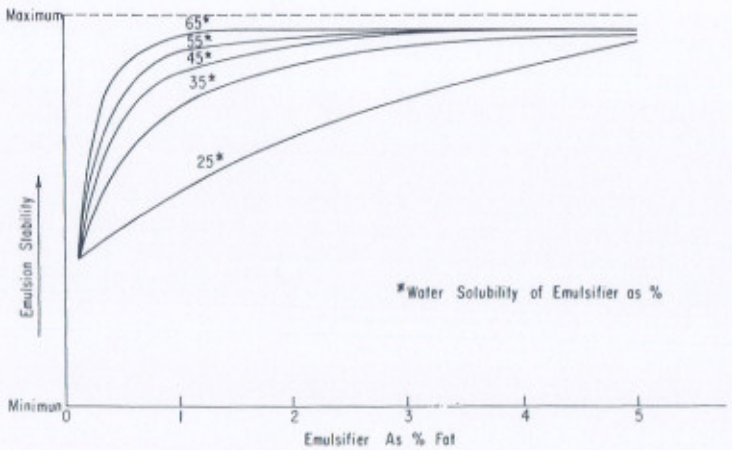

Figure 4. Two-dimensional graph showing the relative stability of emulsions containing 30 percent fat and 70 percent water with emulsifier levels of 1, 3 and 5 percent of the fat (0.3, 0.9 and 1.5 percent of the total emulsion).

baked goods. An emulsifier with a low water solubility needs to be added so the average water solubility is 45-65 percent. It usually is easier just to start with the anhydrous milk fat and add a single emulsifier of the proper solubility.

Cost of Emulsifiers

Emulsifiers currently can be bought for about 50 cents per pound. If added to a shortening at the rate of 1 percent, the emulsifier would add only ½ cent per pound to the ingredient cost of the shortening. If this shortening were added to a cake recipe calling for 12 percent shortening (as does the recipe in Table 1) the emulsifier in the shortening would represent only 0.5 percent of the total cake recipe and an additional ingredient cost of only 0.05 cents. This seems like a small price to pay for the vast improvements in texture which the emulsifier will cause, and a small price to pay for the improved flavor which results when milk fat is used in the cake (1, 2).

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The Effect of Uterine Environment on Sperm Cells

Steven Fancy, Mark Hodson and Milton Wells

Story in Brief

The problem is lack of knowledge as to the effects of uterine environment on sperm cell morphology and livability. In this study, several cows were inseminated with sperm cells with known characteristics. Then cells were recovered at various intervals after insemination and changes in their characteristics were determined. Results to date indicate that the cells die and age at a rapid rate in the uterus. The study is continuing in an effort to better define the effects of uterine environment on sperm cells.

It has been known for several years that optimum fertility is achieved when viable sperm cells are placed in the cow in the latter half of standing heat (Trimberger, 1944, 1948; Van Demark, 1952). This procedure assures that the sperm cells are in the cow's uterus several hours before fertilization occurs. The bovine sperm cell apparently has to undergo some changes, usually termed capacitation, before the cell can fertilize the egg cells. These changes occur within a few hours after being placed in the uterus and are a result of some property of the uterine environment.

All of the changes are not yet clear, however, the acrosome, the anterior cap-like structure on the sperm cell is apparently involved. At the present time, it is not clear whether the changes are in the shape of the cell, functional capability of the cell or both (Bedford, 1963, 1964). It is known that sperm cells undergo structural changes in the uterine environment (Bedford, 1970). This is an aging process and can be followed to a degree by determining the condition of the acrosome (Awa, 1970; Wells and Awa, 1970). Few researchers have undertaken to determine the effects of the cow's uterine environment on the sperm cell. The purpose of the work being reported was to obtain a clearer understanding of what happens to sperm cells after they are placed in the cow.

Experimental Procedure

The effects of uterine environment on the percentage of live cells and the percentage of aged cells were measured using 9 cows from the Oklahoma State University herd. The percentages of live cells and aged cells were determined on ejaculates collected just prior to insemination. Each cow was inseminated with 1 ejaculate (approximately 5 cc). Sperm cells were recovered at 30 minutes, 1, 2 and 4 hours after insemination by inserting a stainless steel breeding catheter, with several openings in the anterior 1 inch, into the uterine chamber and, with gentle vacuum, removing a small sample of the cells.

Determinations of the percentages of live cells and aged cells were made on these samples within a few minutes after recovery from the cow. The cows were given routine herd rations and were housed and managed in conventional herd practices. Only 2 of the cows in this preliminary study were in heat on the day of insemination. Further trials will utilize cows that are in heat.

Results and Discussion

The sperm retrieval process as described previously worked reasonably well. It was progressively more difficult to retrieve large numbers of cells at the later periods after insemination. Even though 5 cc. of semen, approximately 5 billion sperm cells, were placed in the cow, it was difficult to consistently secure large numbers of cells at the 4-hour retrieval period. Limited attempts were made to secure cells from 8 to 24 hours after insemination and rarely could sufficient numbers of cells be retrieved to make the desired determinations. This limitation did not allow us to gather any information on the effect of a 12 to 18 hour period in the uterus on sperm cell characteristics. Slaughter trials will likely have to be used to secure this needed information. This problem has been encountered by other researchers and likely explains why so little information is available on what happens to a population of sperm cells after they are placed in the uterus of the cow.

The changes in sperm cell characteristics in the first 4 hours in the uterus were striking. The average effect of the uterine environment on the percentage of live cells is shown in figure 1. The average percentage of live cells in the original ejaculates, just prior to being placed in the cow, was 73.4 percent. At the first retrieval period 30 minutes later, the percentage of live cells had dropped to 46.3 percent and remained at about the 50 percent level at both the 1 hour and 2 hour post-breeding samplings. At the 4 hour post-insemination samplings, the proportion of live cells had dropped to 24.1 percent, or, about one-third as many live

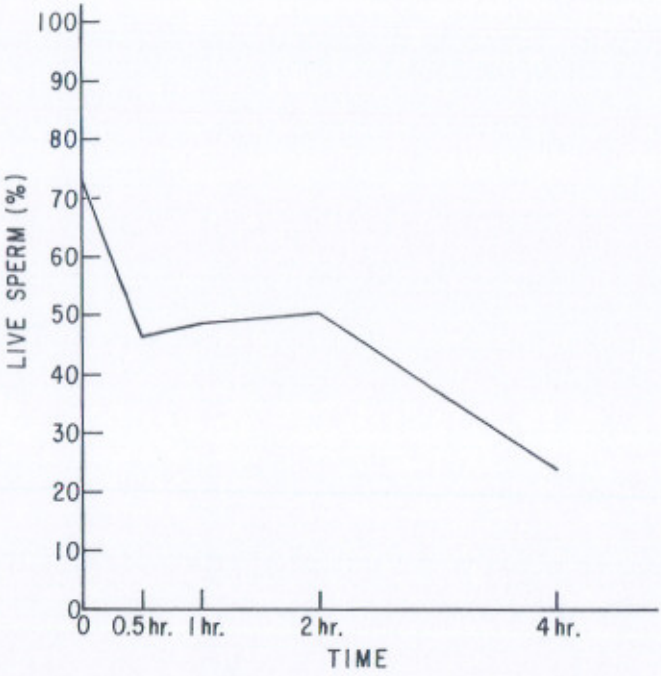

Figure 1. The effect of uterine environment on the percentage of live sperm cells.

cells were present at 4 hours post-insemination as was present at the time of insemination. These samplings were all taken from the uterine horns of the inseminated cows. Although the number of cows is small, the data suggests that sperm cells die rather rapidly after being placed in the uterus. Several factors could be responsible. Most of these cows were not in heat and there was no indication of infection in any of the cows. It should be stated that it may be normal to have this type of sperm cell loss. No data exists to give a good basis for comparison. The next phase of this study will involve a group of cows in standing heat and an attempt will be made to determine if the uterus is a more favorable environment during heat and if various sections of the reproductive system can maintain viability better than others.

The average effect of the uterine environment on the percentage of aged cells is presented in Figure 2. It is normal for all cells to go through the aging process. It is not known at this time at what point in the aging process the fertility of a sperm cell is affected. Our investigations are pointed toward gathering information on this problem. The average per-

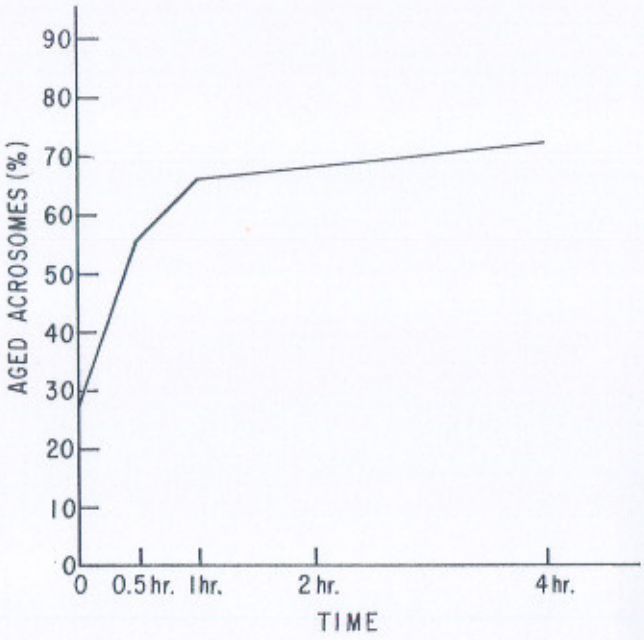

Figure 2. The effect of uterine environment on the percentage of aged acrosomes.

centage of aged cells at the time of insemination was 27.4 percent. Within 30 minutes, the percentage had risen to 55.6 percent and increased to 72.8 percent by 4 hours after insemination. This increase in the percentage of aged cells is again striking. Again, no definitive data exists for good comparisons. The uterine environment changed the levels of aged cells in a short period of time. Whether the uterus of the cow in heat or particular sections of the uterus can maintain the cells more desirably awaits further research.

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SUMMARY REPORTS ON OTHER PROJECTS

Beef Cow-Calf

Beef Cattle Selection Studies

R. R. Frahm

The beef cattle selection study being conducted at the Ft. Reno Livestock Research Station was designed to determine how much genetic response can be obtained from selections based solely on weaning weight or yearling weight performance. Of particular interest is the genetic relationship between pre- and post- weaning growth rate. The magnitude of this genetic relationship will determine the extent to which breeding stock can be selected at weaning time that are genetically superior for total growth rate. Table 1 presents the design of this experiment.

This is a long term experiment and it will be several years before conclusions can be reached concerning its primary objectives. However, the data being collected in this project have been analyzed to provide answers to other questions confronting the beef industry.

Table 1. Design of Beef Cattle Selection Experiment

	Line Number					
	5	6	7	8	9	10
Breed: H=Hereford, A=Angus	H	H	A	A	A	AH
Number of Cows per Line	50	50	50	50	50	50
Selection Procedure:						
Traits: Wt. at specified age (days)	205	365	205	365	R[1] M	205
Criteria: I=Individual, P=Progeny	I	I	I	I	C	I/P
Number males selected per year	2	2	2	2	2	5/2[2]
Number males selected per year	2	2	2	2	2	2
Number years selected males used	2	2	2	2	2	2
Number females selected per year	10	10	10	10	10	10

[1] Random mating control line. The purpose of this line is to maintain genetic stability so that comparisions between it and the selection lines within a particular year provide a measure of genetic progress achieved in the selection lines.

[2] Five sires initially selected for progeny testing on the basis of their weaning weight performance. The top 2 bulls are selected for use in the line based on progeny weaning weight.

Publications

The following articles have been published from this project during the past year:

Cardellino, Ricardo. 1970. A comparison of different age of dam correction factors for weaning weight in beef cattle. M.S. Thesis, Oklahoma State University.

Cardellino, Ricardo and R. R. Frahm. 1970. Age of dam adjustments for weaning weights of beef cattle. J. Anim. Sci. 31:161 (Abstract).

Deutscher, G. H. 1970. Productivity of Angus-Holstein crossbreds versus Angus heifers under tall grass range conditions. M.S. Thesis, Oklahoma State University.

Frahm, R. R. 1970. Can you select herd bulls at weaning time? Proceedings of the Ft. Reno Livestock Research Station Field Day, Oct. 22, 1970.

Frey, John. 1971. Evaluation of cow type classification score and its relationship to cow productivity. M.S. Thesis, Oklahoma State University.

Tanner, J. E., R. R. Frahm, R. L. Willham and J. V. Whiteman. 1970. Sire x sex interactions and sex differences in growth and carcass traits of Angus bulls, steers and heifers J. Anim. Sci. 31:1058.

Beef Feedlot and Nutrition

Effect of Previous Plane of Nutrition Upon Efficiency of Energy Utilization by Beef Steers

J. E. McCroskey, H. A. Deramus, Jr., R. R. Johnson and D. G. Wagner

Three lots of four Hereford steers each were started on feed in the summer of 1970 to study the effect of level of energy consumption and previous plane of nutrition upon efficiency of energy utilization by beef steers. Efficiency of feed and energy utilization are being determined from feedlot performance, respiration calorimetry, and the slaughter technique.

All lots of steers were individually hand-fed a high-grain finishing ration. One group of steers (lot 1) was fed at maximum feed intake from the start of the study to approximately 1000 lb. A second group (lot 2)

was fed to gain one pound per head daily until lot 1 reached slaughter weight, then put on full feed. The third group (lot 3) was fed at a maintenance level until lot 1 reached slaughter weight, then put on full feed.

Total energy balance was determined at the beginning, at intervals during the feeding period and will be determined just prior to slaughter, using respiration calorimetry and carbon-nitrogen balance. Carcass energy gain will also be determined using the slaughter technique.

The first two lots of steers have been slaughtered and the third group will complete the study about May 1, 1971. This study should show the relative efficiency of feed and energy utilization of beef cattle fed to slaughter weight under three widely different feeding regimes, and should answer some of the questions relating to compensatory gain. Results of the study will be presented in the 1972 report.

Effect of Melengestrol Acetate (MGA)[1] Upon Energetic Efficiency of Feedlot Heifers

J. E. McCroskey and H. E. Kiesling

Three sets of identical twin beef heifers were used in a feeding study to determine the effect of Melengestrol Acetate (MGA) upon energy gains and losses as determined by respiration calorimetry and carbon-nitrogen balance. The heifers were individually fed a high grain ration with both members of a pair fed the same amount of feed. One member of each pair also received 0.5 mg. of MGA daily. Fasting heat production and total energy balance were determined twice during the study.

Results of the study indicate that MGA-fed heifers were less efficient in energy utilization in both balance studies as reflected by lower values for digestible energy, metabolizable energy, and net energy. Energy stored as protein and fat was also lower for MGA-fed heifers. There was an indication of a slight decrease in energy required for maintenance due to MGA feeding as determined by the changes in fasting heat production from the beginning to the end of the study. Thus, the results suggest that when feed intake is limited, efficiency of energy utilization by feedlot heifers is not improved by feeding this level of MGA.

[1]Melengestrol Acetate (MGA) provided courtesy of the Upjohn Company, Kalamazoo, Michigan

Publications

Kiesling, H. E. and J. E. McCroskey. 1971. Energetic efficiency of heifers fed MGA. Southern Section of American Society of Animal Science (Abstract).

Rumen Fermentation Rates In Steers Fed High Concentrate Rations

R. R. Johnson

Much work has been done in the past and more is presently being conducted on the utilization of various processed grains in high concentrate rations for beef cattle. It is now well known that the performance of beef cattle, especially feed efficiency, can be improved by the substitution of certain processed grains for dry rolled or ground grains.

In addition, there are basic differences between the cereal grains themselves in their ability to support performance of finishing beef cattle. Explanations for these differences in performance have not been found, however. During the past year, a new project was initiated to study the rates of synthesis of the volatile fatty acids from various processed grains in the rumens of beef cattle. Although it is well recognized that practically all carbohydrates that are fermented in the rumen are converted to volatile fatty acids which are eventually utilized by the host animal as an energy source, the rate of synthesis of these volatile fatty acids and the ratios of the three major acids, acetic, propionic and butyric acids, can be highly variable.

These variations are presumably associated with performance of the animal. The effects of grain processing and other ration modifications in high concentrate rations on these rates of synthesis have not been studied. During the past year, two preliminary experiments were conducted in which whole shelled corn was compared to ground corn and reconstituted milo was compared to dry rolled milo as the major feed ingredients in high concentrate rations for fistulated beef steers. The levels of lactic acid, volatile fatty acids and pH in the rumens of these animals were measured at various times after feeding. In addition, microscopic examination of the bacteria and protoza were made. Analytical measurements on these samples have not been completed as yet. Presently an automatic feeding device which will allow more accurate measurement of the rate of synthesis in the rumen is being built and tested.

Utilization Of Waste Products In Animal Feeds

Ronald R. Johnson

A new research area which has received more emphases than any other research area in the last year or two is the utilization of waste products from agricultural as well as other industries for some productive purpose. Since many of these waste products are cellulosic in nature, it has logically been suggested that ruminant animal feeds might be the best area in which to utilize them. The ruminant has the natural capacity for digesting many materials such as the fibrous portions of plant tissues and miscellaneous forms of nitrogen which most other animals do not possess. Because of the importance of this type research, the overall area of improving the quality of our environment and the solution to pollution problems, a project is being initiated to study the utilization of waste materials in animal rations.

Basically, this project is designed to cover the study of the utilization of practically any type of waste or by-product that conceivably has a potential as a animal feed ingredient. The initial emphasis will be placed, however, on the utilization of high cellulose type materials in ruminant rations. A tremendous number of cellulose materials are at present accumulated as waste materials causing disposal problems as well as posing potential losses to the industries associated with them. Among these might be listed waste paper, municipal rubbish, residues from the wood-pulping and forest industries, rice hulls, sugar cane bagasse and other similar products of agricultural and industrial enterprises.

Virtually all of these materials contain high proportions of cellulose or fibrous type components, but in addition, almost all of them are highly lignified and, as a consequence, have a very low digestibility, in some cases approaching zero. Thus, it is quite likely that in order for any of these to be utilized as animal feeds, a certain amount of chemical processing will be required to release the usable forms of carbohydrates and other nutrients.

There are numerous chemical treatments which have already been developed which are capable of performing this process but which have not necessarily proven to be economically feasable. It is quite likely that these materials will find a role in the nutrition of animals existing on a maintenance type ration, such as a wintering cow, rather than on the rations that are commonly found in feedlot situations. During the coming year, a number of these products will be examined in laboratory tests and in limited number of animal tests to determine their possible contribution towards the nutritive requirement of ruminants.

Relationship Between Laboratory Characteristics And Intake Of Bermudagrass By Grazing Steers

J. E. McCroskey and D. E. Hopson

Five grazing studies were conducted during the summer of 1969 using eight yearling Hereford steers to determine the consumption of Midland Bermudagrass pasture and to relate intake to certain laboratory characteristics. Forage consumption was determined using an external indicator (polyethylene glycol) to calculate fecal dry matter output, and the lignin-ratio to determine dry matter digestibility. Hand clipped and esophageal forage samples were analyzed chemically for crude protein, acid detergent fiber, acid detergent lignin, and cell-wall constituents. *In vitro* dry matter disappearance was also determined on all forage samples.

Average forage dry matter consumption for the five periods from May to October were 13.4, 13.2, 9.5, 23.5, and 30.6 lb., respectively. The high intake during the last two periods reflects an unusually abundant amount of forage due to heavy rainfall late in the summer. Intake normally would continue to decline throughout the growing season. Statistical analysis of the data showed that voluntary intake was highly correlated with the acid detergent lignin content of the forage samples collected by esophageal fistulated steers (-.93). *In vitro* dry matter disappearance, which is an estimate of forage digestibility, was highly correlated with the acid detergent fiber and cell-wall constituents on hand clipped forage samples (-.97 and -.95, respectively). Results of the study indicate that the acid detergent lignin content of forage samples obtained by esophageal fistulated animals can be used as a predictor of forage intake. Furthermore, increasing fiber and cell-wall constituents have a highly depressing effect upon forage digestibility.

Publications

Hopson, D. E. 1971. The determination of intake and digestibility of harvested and grazed forage by the use of indicators. M.S. Thesis. Oklahoma State University.

Indirect Determination Of Forage Intake Using Indicators

J. E. McCroskey and D. E. Hopson

Determination of forage intake by grazing animals requires (1) a measure of fecal output and (2) an estimate of forage digestibility. This study was conducted to compare different levels and methods of administration of an external indicator for measuring fecal output, and to compare the accuracy of two methods of estimating digestibility.

Four digestion trials were conducted using yearling Hereford steers to compare the accuracy of polyethylene glycol (PEG) given at levels of 50, 100, 150, and 200 gm. per day administered either in single (8:00 a.m.) or split doses (8 a.m. and 4:30 p.m.) to calculate fecal output. *In vitro* dry matter disappearance and the lignin-ratio were compared as estimates of forage digestibility. All steers were fed bermudagrass hay, and feed intake, fecal output, and digestibility were determined directly.

Results of the study revealed that PEG given in split doses gave more accurate estimates of measured fecal output than when given in a single dose. Of the four levels of PEG compared, 150 gm. given in split doses gave the greatest accuracy, however 50 and 100 gm. given in split doses gave fecal output calculations almost as accurate as the 150 gm. level. The 200 gm. level was the least accurate because of low percent recovery.

There was no significant difference between forage digestibility determined by the conventional digestion method and by the *in vitro* technique; however, digestion coefficients determined by the lignin-ratio method were significantly lower ($P<.05$) than those determined by conventional digestion trial. Comparison of actual intake with values calculated using PEG, lignin-ratio, and *in vitro* methods indicates the greatest accuracy was obtained with 150 gm. of PEG given in split doses, and using the *in vitro* procedure to estimate digestibility. In view of the small and non-significant differences in accuracy of fecal output determination between the 50 and 150 gm. levels of PEG, the lower level given in split doses would be more practical and would give essentially the same accuracy in estimating forage intake.

Publications

Hopson, D. E. 1971. The determination of intake and digestibility of harvested and grazed forage by the use of indicators. M.S. Thesis. Oklahoma State University.

Hopson, D. E. and J. E. McCroskey. 1971. Polyethylene glycol as an external indicator. Southern Section American Society of Animal Science (abstract).

Meat and Carcass Evaluation

Influence Of Level Of Potassium Intake on Net K^{40} Count In Beef Steers

Rodger Johnson, L. E. Walters and J. V. Whiteman

Thirty-six Angus-Hereford crossbred steers were used to study the influence of 3 levels of dietary potassium on net K^{40} count, blood serum potassium levels and muscle tissue potassium concentration. The 3 diets (approximately 50 percent roughage-50 percent concentrate) were alfalfa-corn, wheat straw-corn and a diet consisting of 1.7 lbs. KCL added to each 100 pounds of the wheat straw-corn ration. Potassium levels of the 3 diets were 1.31, 0.29 and 1.03 percent, respectively. The steers were alloted into 3 groups and each group placed on one of the above diets for a two-week feeding period. Appropriate K^{40} counts and tissue samples were taken at the end of each feeding period. At the end of the two week feeding period, steers were placed on a different ration so that at the end of 3 two-week periods, each steer had received each ration. K^{40} data were collected on steers unshrunk and after 24 hours shrink. The experiment was balanced so that carry-over effects of each ration from one period to the next could be evaluated.

Statistical analysis of the data indicate that carry-over effects appeared negligible for all treatments. Steers fed the alfalfa diet had the highest net K^{40} count and steers on wheat straw the lowest. This difference was considerably larger when determined on unshrunk steers than after the same steers were shrunk for 24 hours (without feed and water).

Preliminary analysis of the data indicate that the difference after 24 hours shrink is large enough to suggest that the diet cattle are receiving prior to K^{40} counting may influence the accuracy of K^{40} estimates of lean in cattle. Dietary potassium levels appeared not to influence blood serum potassium levels or muscle tissue potassium levels. However consistent differences between animals were evident in blood serum and muscle tissue potassium concentrations.

These data indicate that if estimates of lean in cattle are to be made from K^{40} net count, the same ration should be fed to all animals for a period of time prior to counting. Thus it appears that the K^{40} counter is the best adapted to comparison of similar weight animals that have been fed and managed alike for a period of time prior to K^{40} evaluation.

These data are undergoing further analysis and a more complete report will be available at a later date.

Net K^{40} Count As A Predictor Of Fat-Free-Lean In Cattle And Swine

Lowell E. Walters

Recently, certain support instrumentation has been added to the equipment at the Live Animal Evaluation Center which is needed in the calibration and maintenance of the K^{40} counter. Through the incorporation of these facilities into the evaluation program, improvement may be achieved in the capability of the counter to predict pounds of fat-free-lean in both cattle and swine. The following described studies incorporating these facilities are in progress.

Cattle

Thirty-six 900-1000 pound Choice quality slaughter steers were counted in the whole-body counter at the Live Animal Evaluation Center in the fall of 1970 for the purpose of re-evaluating K^{40} net count as a predictor of total muscle in beef steers. The steers were alloted to six groups and were processed through the Evaluation Center and the O.S.U. Meat Laboratory during six successive weeks. The steers were thoroughly washed and shrunk for 24 hours prior to counting. Five 2 minute counts were taken for each steer.

Following slaughter, the right half of each carcass was separated into lean, fat and bone. The separable lean was sampled for chemical analysis which is currently in the final stages of completion. Ether extract content of the separable lean will be used in order to determine the total quantity of fat-free-lean for each animal. Statistical analysis of the data will be completed to ascertain the relationship between net K^{40} count and pounds of total fat-free-lean.

Hogs

Earlier research designed to monitor muscle development in growing and finishing swine using the large cattle K^{40} counting equipment pointed to the need for a different detector arrangement, especially for 100-200 pound pigs. It appeared from this work that for greater counting efficiency, the detector logs needed to be much closer to the pigs than was possible in the larger cattle arrangement: therefore, six detectors were remounted in a smaller configuration and an experiment conducted to determine the improvement, if any, with "lean cuts" in the carcasses from counted animals as the end-point. Since this study showed promise of improvement in counter efficiency using the new detector design, 23 Hampshire, 21 Duroc and 21 Yorkshire market barrows weighing 215 pounds were counted in the fall of 1970 to further study counting efficiency.

In this work the animals were thoroughly washed and shrunk 24 hours prior to counting. After slaughter, the warm carcasses were mounted in a standing position and returned to the counter for carcass counting efficiency studies. The carcasses were chilled, split and the right half separated into lean, fat and bone. The separable lean was sampled for chemical analysis which is nearly completed at this writing. Fat-free lean determination will be made from ether extract analysis of the ground lean samples from each carcass and all the data treated statistically.

Estimation Of Fat Thickness And Loin Eye Area By Ultrasound

Lowell Walters and Michael May

During recent years, several probing techniques have been studied in efforts to learn more about the composition of meat animals without resorting to slaughter and chemical analysis of the animals. Among these techniques is that of ultrasound, of interest primarily because of its promise in providing some information relative to thickness of subcutaneous fat and the size (shape) of muscles such as the loin eye in the animal alive. These two estimates of composition have been shown to be of some value as predictors of composition.

Ultrasonics refers to sound waves or vibrations at a frequency above the audible range of the human ear. This ultrasonic energy is mechanical vibration that can be focused in a narrow beam which may be transmitted and reflected in much the same way as a beam of light. The technique is useful in animal appraisal because of the differential rate of transmission of the sound in tissues that differ in density such as fat and lean. Thus, when a beam of these sound waves passes from fat into lean, an "echo" is established in the calibrated instrument from which a fat depth and a muscle size and shape can be estimated.

The Scanogram is an instrument under study in this research which makes use of this principle, coupled with a Polaroid film pack and a mechanically synchronized drive which makes possible a plot of "echos" representing fat layers and muscle systems on the Polaroid film.

Results from studies with slaughter cattle and hogs indicate that the Scanogram can estimate fat thickness in both species with greater accuracy than loin eye area. With cattle, the results have been somewhat variable depending upon the function of the electronics in the instrument. Aver-

age errors for fat thickness and rib eye area at the 12th rib location on one group of ninety-eight 1000 lb. steers were found to be 0.17 inches and 0.59 square inches, respectively. The average errors for a group of thirty-six 1000 pound slaughter steers were 0.11 inches and 0.74 square inches for fat thickness and rib eye area, respectively. A second group of 36 slaughter steers was evaluated at a time in which the machine was less stable and in this case, rib eye areas were missed on the average by 1.28 square inches and fat thickness by 0.17 inches.

In the studies with 200-225 pound slaughter barrows and gilts the results have also been quite variable. In one group of 16 market barrows, the average error for loin eye area estimates was 0.63 square inches and for backfat thickness, .096 inches. With another group of 67 market weight hogs the average errors for fat and loin eye area were found to be 0.10 inches and 0.84 square inches, respectively. The correlation between estimated fat thickness and percent lean cuts of live weight was -0.65. In the fall of 1970, a group of 43 market hogs were evaluated by the Scanogram in a somewhat different fashion to include an estimate of fat thickness made on the midline of the back from the thirteenth rib to a point eight inches posterior. In this work the correlation between actual "linear fat" and the estimated was found to be +0.78. However, correlations between the linear fat estimate with lean cut yield and estimated average backfat thickness with lean cut yield were found to be almost identical (-0.59 and -0.58).

Mouse Selection Studies As An Aid To Animal Breeding Research

R. R. Frahm, I. T. Omtvedt and C. R. McLellan, Jr.

The economic importance of growth rate is well recognized by all segments of the livestock industry. It is most desirable from the standpoint of efficiency to select breeding stock with superior genetic capability for rapid growth at the earliest age possible. Determination of the optimal age at which selections can be made effectively requires a basic understanding of the genetic relationships that exist among growth rate at different stages of the growth curve. Experiments are underway with the livestock species to provide information on this very fundamental question, however, it will be several years before adequate answers will be available. This type of research requires large numbers of experimental

animals to obtain good measurement of these genetic relationships coupled with the fact that it is a slow process because of the long generation intervals involved with the livestock species.

Mice are well suited for genetic studies to explore basic genetic relationships and provide an indication of what can be expected with the livestock species. Large numbers of mice can be economically maintained in a relatively small amount of space under well controlled environmental conditions. Since 4 generations are produced each year, results are obtained considerably faster with mice than with the livestock species.

Project 1405 was initiated to measure direct and correlated response to selection for preweaning and postweaning rate of gain in mice for the purpose of determining the basic genetic relationships between growth rate at these two intervals in the life cycle. This project consists of 6 selection lines of 20 litters each (3 lines selected on basis of individual weaning weight and 3 lines selected on the basis of weight gain from 3-6 weeks of age) and a random mating control line of 40 litters that is used for measuring genetic changes that occur in the selection lines.

After 2 generations of selection, the average 3-week weight of the 3 lines selected on the basis of weaning weight was 0.76 gram (7.5 percent heavier than the control lines and the average daily gain from 3-6 weeks of age for the 3 lines selected for postweaning growth rate was 0.072 gram/day (11.0 percent greater than the control lines which indicates that direct selection for these two traits has been effective. Average daily gain from 3-6 weeks was essentially the same in the weaning weight selection lines as the control lines indicating little correlated response to date for postweaning gain. However, the average 3-week weight of the postweaning gain selection lines was 0.48 gram (4.7 percent) heavier than the control lines indicating that some correlated response for 3-week weight has apparently been realized.

In order to determine if the total weight of a particular muscle system can be altered by selection, a study involving two selection lines has been initiated. One line is being selected on the basis of the heaviest weight of the hindquarter muscle system and the other on the basis of the lightest muscle weight in the mature mouse (12 weeks of age). After 3 generations of selection, the heavy-muscle line had an average hindquarter muscle weight of 2.59 gram which was 14.1 percent heavier than the 2.27 gram average muscle weight of the light-muscle line. These results indicate that direct selection to alter the weight of a specific muscle system has been effective to date, however, more generations of data will be required to reach specific conclusions. Of particular interest in this study will be whether live weight of the mice change proportionally with the alteration in muscle weight or whether the altered muscle weight will reflect a change in the ratio of muscle weight to live weight.

Hot Boning Of Bovine Muscle

C. L. Kastner and R. L. Henrickson

Processing meat prior to chilling is of commercial interest; consequently, extensive research has been conducted on porcine muscle. Bovine muscle has received limited attention, thus a meaningful research project would consist of evaluating "hot boning" of the beef carcass.

Fabrication of th bovine carcass prior to chilling has several potential advantages. The economy of this process is reflected by the fact that waste fat (20-30 percent) and bone (15-18 percent) are removed prior to chilling thus conserving on cooler space and total refrigeration input. A boneless closely trimmed product, produced from "hot boning" could lend itself well to portion control and marketability.

The objective of this investigation is to evaluate the feasibility of "hot boning" of the U.S. Good grade beef carcass with respect to yield, juiciness, tenderness, flavor, and color.

Even though this current research project is not completed there are some indicated trends considering the test parameters. When "hot boning", yield does not appear to be significantly different from boning a cold carcass. Removing muscle from the skeleton while it is still hot appears to have no marked effect on the flavor or juiciness as evaluated by a taste panel, percent moisture, or the Carver Press. Fresh meat color is slightly darker for the hot boned muscle but this color is not undesirable. Color differences are difficult to detect unless a direct comparison is made with the cold boned muscle. To date all color results have been based on visual color panel evaluations.

In conjunction with the panel, a Photovolt Reflection Meter is used to objectively measure hue, value, and chroma so that the authors will substantiate the visual color apprasial. Tenderness appears to be the primary problem when muscles are removed from the hot carcass. This would be expected because hot excised muscle can freely contract during rigor mortis. Muscles left on the skelton until rigor is complete, do not extensively contract due to their muscle and/or bone attachments. Therefore the cold boned muscles are more tender as evaluated by a tenderness panel and the Warner-Bratzler shear apparatus.

With minor modifications in the existing process, the authors feel that the tenderness problem may be resolved.

The Effect Of Ethylene Diamine Tetraacetic Acid On Bovine Myosin Adenosine Triphosphatase

J. J. Guenther

Bovine myosin was isolated from the longissimus dorsi muscle of mature, choice-grade hereford steers. Myosin ATPase activity was determined at 0°C and expressed as micromoles inorganic phosphate released per milligram protein per minute.

Factors studied were Ethylene Diamine Tetraacetic Acid, E.D.T.A. level (0, .005, .01, .02, .04mM/ml), ionic strength of ATPase incubation system and the influence of Ca^{++} activation. Results showed that both E.D.T.A. and the ionic strength of the incubation system had a highly significant effect on myosin ATPase activity and that the effect of E.D.T.A. was strongly influenced by the ionic strength of the incubation system. E.D.T.A. functioned as an ATPase activator in the high ionic system, but as an inhibitor at low ionic strength.

In the high ionic strength system, with no added $CaCl_2$, maximum ATPase rate occurred at 0.01 mM concentration of E.D.T.A.; whereas in the presence of $CaCl_2$, maximum acceleration did not occur until the E.D.T.A. concentration exceeded that of $CaCl_2$. It was also noted that E.D.T.A., at a concentration equivalent to $CaCl_2$ (0.01 mM), had a greater activating effect on myosin ATPase than Ca^{++}. In the low ionic strength system, which contained $CaCl_2$, E.D.T.A. suppressed myosin ATPase activity. The addition of E.D.T.A. had little effect on myosin ATPase activity in the low ionic strength incubation system which did not contain $CaCl_2$. Partially supported by Market Quality Research Division, ARS, USDA, Cooperative Agreement 12-14-100-9348 (51).

Amino Acid Composition Of Bovine G-Actin

J. J. Guenther

Bovine G-actin was purified according to procedures previously reported. Amino acid analyses were carried out on a Beckman Model 120C automatic amino acid analyzes according to the standard methods of Stein and Moore. G-actin samples (4.8305 mg/ml) were acid hydrolyzed at 110°C for 12, 24 and 72 hours in sealed, evacuated tubes.

The values for threonine, serine and half-cystine were determined by extrapolation of the data to zero time of hydrolysis, since these amino acids were partially destroyed when exposed to prolonged acid hydrolysis. The value for ammonia was calculated by subtracting losses in serine, threonine and half-cystine after 24 hours hydrolysis, from the observed ammonia value at 24 hours.

The data from the amino acid analyses are shown in Tables 1, 2, and 3. After 12, 24 and 72 hours acid hydrolysis amino acid recovery was 96.35, 97.44 and 89.92 percent, respectively. A significant difference existed between recoveries at the 12 and 72 hour period.

At the 24 hour period, 57 glutamic acid and 44 aspartic acid residues were obtained (Table 2). This indicates that the isoelectric point of bovine G-actin is on the acidic side. Methionine had the smallest number of residues, 7 per molecule. Bovine G-actin also contained considerable quantities of neutral amino acids such as alanine (38 residues/mole), glycine (36 residues/mole) and leucine (34 residues/mole). These values agree with G-actin from rabbit muscle. However, rabbit G-actin has a much greater amount of sulfur-containing amino acids. For example, rabbit G-actin contains 20 methionine residues per mole, whereas bovine G-actin contains only 7.

The minimal molecular weight of bovine G-actin can be calculated

Table 1. Amino Acid Recoveries After Acid Hydrolysis

	mg/4.8305 mg G-action		
Amino Acid	12 hr hydrolysis	24 hr hydrolysis	72 hr hydrolysis
Lysine	0.22141	0.24601	0.23898
Histidine	0.10550	0.13188	0.12412
Ammonia	0.80743	0.08045	0.06889
Arginine	0.26828	0.28396	0.27176
Aspartic Acid	0.46718	0.47117	0.44508
Threonine	0.31442	0.30132	0.26392
Serine	0.21858	0.20282	0.15385
Glutamic Acid	0.63707	0.67091	0.59205
Proline	0.20953	0.20147	0.09249
Glycine	0.22070	0.21770	0.21019
Alanine	0.28508	0.27439	0.26156
Half-cystine	0.10572	0.08169	0.06343
Valine	0.20852	0.23312	0.23804
Methionine	0.09549	0.08206	0.07281
Isoleucine	0.29250	0.30562	0.31375
Leucine	0.35022	0.36858	0.34419
Tyrosine	0.27359	0.27359	0.22032
Phenylalanine	0.18666	0.20153	0.18104
Unknown	0.10624	0.07864	0.08720
	4.65412	4.70691	4.34367
Recovery %	96.35%	97.44%	89.92%

Table 2. Numbers of Amino Acid Residues per Molecular Weight=60,-000 G-Actin

Amino Acid	12 hr hydrolysis	24 hr hydrolysis	72 hr hydrolysis
Lysine	23.4758	26.0842	25.3389
Histidine	8.4463	10.5579	9.9368
Ammonia	63.8443	58.7516	50.3053
Arginine	19.1284	20.2463	19.3768
Aspartic Acid	43.5979	43.9706	41.5360
Threonine	32.7916	31.4253	27.5251
Serine	25.8358	23.9726	18.1844
Glutamic Acid	53.7832	56.6400	49.9824
Proline	22.6063	21.7368	20.7680
Glycine	36.5179	36.0211	35.7790
Alanine	39.7474	38.2569	36.4682
Half-cystine	5.4652	4.2231	3.2791
Valine	22.1095	24.7179	25.2396
Methionine	7.9494	6.8315	6.0614
Isoleucine	27.6989	28.9411	29.7112
Leucine	33.1642	34.9032	32.5928
Tyrosine	18.7558	18.7558	15.1040
Phenylalanine	14.0358	15.1537	13.6134
Unknown	9.5642	7.0800	7.8501

Table 3. Amino Acid Composition of Bovine G-Actin

Amino Acid	Residues[1] per molecule[2]	gm per molecule[2]	Residue % (moles)	Weight % (gm)
Lysine	26.0842	3055.7640	5.13	5.12
Histidine	10.5579	1638.1637	2.08	2.75
Ammonia	49.8034[3]	847.2408	9.80	1.42
Arginine	20.2463	3527.1079	3.98	5.92
Aspartic Acid	43.9706	5852.4868	8.65	9.82
Threonine	34.1579[4]	4068.2058	6.72	6.82
Serine	27.6990[4]	2910.3879	5.45	4.88
Glutamic Acid	56.6400	8333.4432	11.14	13.93
Proline	21.7368	2502.5577	4.28	4.20
Glycine	36.0211	2704.1039	7.09	4.53
Alanine	38.2569	3508.3072	7.53	5.72
Half-cystine	6.7073[4]	1611.6971	1.32	2.70
Valine	24.7179	2895.7019	4.86	4.86
Methionine	6.8315	1019.3281	1.34	1.71
Isoleucine	28.9411	3796.2040	5.69	6.37
Leucine	34.0932	4573.2527	6.87	7.68
Tyrosine	18.7558	3398.3634	3.69	5.70
Phenylalanine	15.1537	2503.2397	2.98	4.20
Unknown	7.0800	976.8984	1.39	1.64
	508.2696	59627.4541		

[1] Values taken at 24 hours hydrolysis.
[2] Assumes M. Wr. of 60,000.
[3] The value for ammonia was obtained by subtracting losses in serine, threonine, and half-cystine after 24 hours hydrolysis, from the ammonia value at 24 hours.
[4] Extrapolated value.

from its amino acid composition. Assuming one mole of methionine per mole of protein, a value of 8,782.7 is attained. If 7 methionine residues were present per molecule of G-actin, the molecular weight would be about 61,479. If molecular weight is computed in terms of tyrosine residues, the result is about 60,781. Partially supported by Market Quality Research Division, ARS, USDA, Cooperative Agreement 12-14-100-9348 (51).

Swine

Selection For Crossing Ability In Swine

I. T. Omtvedt

The basic objective of Project 808 is to study the feasibility of selecting purebreds on the basis of their ability to cross. Sow productivity traits generally exhibit considerable hybrid vigor in crossbreeding studies, but unfortunately, these traits are lowly heritable and show very little response to direct selection. The hybrid vigor obtained in crossbreeding is "one-shot improvement" and breeders cannot expect to obtain increased performance due to additional heterotic response each generation. In this project an effort is made to make continued improvement in two-breed crossbred gilts by selecting the two parent lines on the basis of their crossing ability. The basic procedure is to select the Duroc and Beltsville boars and gilts for breeding on the basis of their Duroc-Beltsville crossbred half-sisters' productivity (litter size and 21-day weight).

The project is currently in the sixth generation of selection. Productivity of the crossbreds has been very desirable but continual improvement in the crossbreds over the controls each generation is not readily apparent at this time. This procedure is widely used in plant breeding and research with laboratory organisms indicated that it may have application in swine breeding, but results to date are not very encouraging. This project will be phased out at the end of sixth generation.

The project is currently in the sixth and final generation of selection. The productivity of the Duroc-Beltsville No. 1 crossbred gilts compared to the productivity of the control line gilts will be used to evaluate the effectiveness of selection for crossing ability. An analysis of the control line data from 1961 to 1970 showed that performance and productivity

for this line remained relatively stable during the course of this experiment so should be a valid basis for comparing possible improvement in the selected lines. Preliminary analyses of the records do not reveal any steady divergence in productivity of the 2-line cross from the control live gilts. In the sixth generation, the selected line farrowed larger litters (10.5 vs. 10.1) of heavier pigs (2.6 lb. vs. 2.2 lb.) but the differences in litter size at 21 days were relatively small (8.8 vs. 8.7). The average pig 21-day weight was 11.6 lbs. for the crossbreds compared to 10.5 lbs. for the controls.

Publications

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Robbins, B. S., W. G. Luce, I. T. Omtvedt. 1971. Pelleting milo and wheat for swine. J. Anim. Sci. 32:390.

Omtvedt, I. T. 1970. Swine crossbreeding studies. Proceedings of Oklahoma Swine Short Course. Page 7.

Genetic Evaluation Of Purebred And Crossbred Performance Of Duroc, Hampshire And Yorkshire Swine

I. T. Omtvedt

The fact that approximately 90 percent of the pigs marketed in the U.S. today are estimated to be of crossbred origin indicates that swine producers recognize the benefits of crossing. The two basic reasons for crossing are:

1. To obtain hybrid vigor or heterosis.
2. To combine the strong points of the different breeds.

Much of the crossbreeding research with swine has been conducted at Oklahoma and the general response expected for most traits has been established. In general, crossbred sows farrow and raise larger litters than

the average for the breeds making up the cross. In addition to crossbred pigs being more rugged and having greater livability, they are heavier at weaning and gain faster during the postweaning period thus resulting in their reaching market weight at an earlier age. No consistant advantage of crossbreds over purebreds for either feed required per unit of gain or carcass merit has been demonstrated.

Even though the general results expected from crossings are known, data on specific crosses and crossing sequences that will yield maximum performance in a breeding program are not available. Most of the early investigations involved inbred lines and breeding stock typical of that time under management conditions quite different from those recommended today. Breed differences in productivity, growing ability and carcass merit are known to exist, but how to best combine the breeds to obtain maximum overall performance is not known. How important is maternal influence? In a 2-breed cross, does pig performance vary depending on which breed is used as the sire and which breed is used as the dam? In a 3-breed cross, which breed combinations make the best female and which combinations result in best overall performance? These are very important questions to a swine producer when he lays out his crossbreeding program.

In an effort to answer these questions and to re-evaluate the response expected from crossbreeding using modern-type breeding stocks, project 1444 was initiated to evaluate the combining ability of the Duroc, Hampshire and Yorkshire breeds in 2-breed and 3-breed crosses.

Three purebred herds were established at the Experimental Swine Farm at Stillwater to provide the seedstock for this project. In Phase II purebreds are compared to the 2-breed crosses while in Phase II the productivity of crossbred gilts and purebred gilts from Phase II are evaluated in 3-breed and 2-breed crosses. Phase II involves 135 matings and Phase III 144 matings during each 6 month period. One-third of gilts in each group will be slaughtered one month after breeding to determine ovulation rate and embryo survival. Sow productivity will be evaluated at birth, 21 days and 42 days. Postweaning growth rate, feed efficiency, probe backfat thickness and carcass data will also be obtained.

Results not yet available. The first pigs for this project were produced at Stillwater between February 24 and April 20, 1970 and consisted of 21 Duroc litters, 25 Hamp litters and 25 York litters. From these litters, 45 gilts and 5 boars from each of the 3 breds served as the seedstock for Phase II at Ft. Reno. In November, each of these 15 boars were mated to 3 gilts of their own breed and 3 gilts from each of the other 2 breeds. Fifteen gilts from each breed (one gilt from each mating type for each boar) are being sacrificed 25 days postbreeding to evaluate ovulation rate and early embryo survival. The other 30 gilts of each breed will be carried

full term to produce the seedstock for Phase III. In 1970 fall, 24 Duroc litters, 28 Hamp litters and 23 York litters were farrowed at Stillwater and pigs from these litters will be mated at Ft. Reno in 1971 spring to serve as the second replication of Phase II. New boars are continuously being introduced into the 3 foundation herds at Stillwater to maintain a broad genetic base for each breed.

The Effect Of Ration Ingredient Change On Pig Performance

W. G. Luce and C. V. Maxwell

One trial was conducted involving sixty-four growing-finishing swine to measure the effect of ration ingredient change.

Treatments involved were: (1) A basal milo-soybean meal ration fed throughout the trial; (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) were rotated every 7 days; (4) Both the cereal grain and protein sources, as outlined in treatments 2 and 3, were rotated every 7 days (9 different combinations). Average daily gains, average daily feed intake, and feed efficiency were similar for all treatments.

The data is presently being further analyzed. Another trial is also being planned at a later date.

The EffectOf Temperature And Humidity Upon The Performance Of Growing Swine

R. A. Battaglia

The first replicate of a study to determine the effects of adverse environmental conditions upon "doing ability" in growing swine has been completed.

Six gilts, averaging 40 pounds in weight were allotted, three each, to either a 90 degree F. group or to a 70 degree F. group. The relative humidity was held constant in the 45-50 percent range. The replicate lasted for 28 days, during which time the gilts were maintained in the environmental chambers on the Stillwater campus. Floor space allotment was 6.8 square feet per animal, with one half of each of the floor area being expanded-metal and plywood. Feed and water was available *ad-libitum*. Rectal temperatures and respirations rates were taken at 6 a.m. and 6 p.m. daily.

Results for the cool (70 degree F) group and hot (90 degree F) group respectively are as follows: rectal temperature, 102.7 vs. 103.5; respiration rate, 27 per minute vs. 75 per minute; daily feed consumption, 3.5 pounds vs. 2.6 lb; average daily gain, 1.59 lb. vs. 1.16 lb.; total gain for 28 days, 44.7 lb. vs. 32.5 lb.; water consumption 3.5 qt. vs. 4.6 qt. All figures, where applicable, are group averages for 28 days.

It is the purpose of this study not only to demonstrate differences such as those listed above but also to elucidate what physiological phenominia are responsible for these differences With this in mind, histological preparations are being made of the appropriate endocrine glands from one gilt taken from each group at the completion of the study.

Nutrient Requirements For Artifically Reared Young Pigs

C. V. Maxwell, James A. Coalson and J. C. Hillier

Ninety-one baby pigs, obtained by caesarean section on the 113th day of gestation, were used to perfect artificial rearing techniques in a total of five trials. Each pig was placed in a sterile cardboard incubator equipped with a metal feeding tray and was provided with a constant supply of heated, sterilized air. Pigs were fed five times daily beginning at 6:00 a.m. and terminating at 10:00 p.m.

The diet was 21 percent milk solids fortified with minerals and vitamins. Feeding was accomplished with the use of a 50 cc plastic syringe equipped with a 12 gauge needle. The needle was inserted through a rubber stopper to place the diet in the metal feeding tray. The initial amount of feed was 30 milliliters. This was increased by 5 ml. at each successive feeding provided the diet had been consumed within 30 min-

utes. Percent survival ranged from 83 to 100 percent for the different trials with an average survival rate of 90 percent.

Total gains for the 21 day period ranged from 8.72 pounds to 10.83 pounds with an overall average gain of 9.21 pounds. Efficiency of gain as measured by pounds of dry matter intake per pound of gain ranged from 0.76 to 1.15 for the five trials. The gains obtained with this artificial rearing system were comparable to those obtained under normal rearing conditions.

In a separate study, the sows used in the above surgical procedures were rebred after 2 estrus cycles following surgery and allowed to go to term. The six Yorkshire and six Hampshire sows farrowed an average of 8.5 and 9.5 live pigs, respectively. Five stillborn pigs occurred in two of the Yorkshire litters. For this same time period, 23 Yorkshire and Hampshire sows in the University herd farrowed litter averages of 9.9 and 9.3 live pigs, respectively. Caesarean section surgery had no apparent effect on the rebreeding and subsequent litter size of the 12 sows used in this study.

Publications

The following articles were published from this project during the past year:

Coalson, J. A., C. V. Maxwell, E. C. Nelson and J. C. Hillier. 1970. Studies of the Ca and P requirements of young SPF pigs. J. Animal Sci. 31:198 (Abstract).

Coalson, J. A., J. C. Hillier, R. D. Washam, E. C. Nelson and C. V. Maxwell. 1970. Calcium and phosphorus studies with young pigs. Okla. Agr. Exp. Sta. Mp-84:65.

Maxwell, C. V. 1970. Calcium requirements for young pigs. Proceedings of the 12th Annual State Swine Short Course, Stillwater, Oklahoma. Page 28.

Coalson, J. A., I. L. Anderson, C. V. Maxwell and J. C. Hillier. 1971. Effect of Caesarean surgery on sow performance. J. Animal Sci. 32:375. (Abstract)

Coalson, J. A., C. V. Maxwell and J. C. Hillier. 1971. Techniques for rearing caesarean derived pigs. J. Animal Sci. 32:375. (Abstract)

The Effect Of Protein And Amino Acid Nutrition On The Reproductive Performance Of Sows And Gilts

C. V. Maxwell

A total of 30 Yorkshire gilts were fed diets containing 8, 14 or 20 percent crude protein from 135 days of age until they were slaughtered at 28 days post coitum. These diets were fed at the rate of 5 pounds per head per day from 135 to 180 days of age and 4 pounds per gilt per day after 180 days of age. Constant amino acid ratios were maintained by diluting the 20 percent protein diet with cornstarch.

A higher weight gain was noted for each increase in level of crude protein. Gilts fed the high and low levels of protein showed increased age at puberty. No differences were noted in the number of corpora lutea present at 28 days post coitum. There was, however, a decrease in the number of embryo observed as the level of protein was decreased. Percent embryo survival decreased from 93.4 percent in pigs fed the high level of protein to 79.2 percent in pigs fed the low level of protein.

Publications:

Maxwell, C. V. 1970. The effect of protein and amino acid nutrition on the reproductive performance of gilts. Proceedings of 12th Annual State Swine Short Course, Stillwater, Oklahoma. Page 16.

Effects of High Ambient Temperatures On Sow Reproductive Performance

I. T. Omtvedt, E. J. Turman and D. F. Stephens

Two trials involving a total of 126 gilts were conducted to investigate the effect of high ambient temperatures immediately following breeding, during second week postbreeding, during midpregnancy and during late pregnancy on the reproductive performance of first-litter gilts. Although exposure to heat stress during the first and second weeks postbreeding resulted in fewer viable embyros at 30-days postbreeding, exposure during the second week had the greatest adverse affect on embryo survival.

Productivity of gilts subjected to either the control chamber or hot chamber during midpregnancy was comparable to those maintained outside full term. Pronounced adverse effects of high ambient temperatures were noted during late pregnancy. Gilts subjected to the hot chamber in late pregnancy farrowed fewer live pigs and more stillborn pigs. There was a trend for pigs from heat-stressed gilts to be lighter at birth but these differences were not significant. Results indicate that high ambient temperatures have an adverse effect on sow productivity during early and late pregnancy with gilts being more resistant to this stress in midpregnancy.

Another trial involving 60 crossbred gilts was initiated to evaluate the influence of heat stress during estrus. The gilts were confined to the environmental chambers on the 15th day after being observed through at least two normal estrous cycles. The hot chamber was maintained at 96°F for 8 hours and reduced to 90°F for the remaining 16 hours during each 24 hour period with the control chamber maintained at 74°F continuously. Ten gilts maintained in each chamber were slaughtered between 53 to 69 hours after first service to evaluate fertilization rates and the other 20 gilts allotted to each chamber were slaughtered 25 days after breeding to evaluate early embryo survival.

The hot chamber gilts were transferred to the control chamber two days after breeding and maintained with the control chamber gilts until they were slaughtered 25 days postbreeding. Although the data are being analyzed at the present time, it appears that heat stress prior to and during estrus caused no sizeable adverse affects on either ovulation rate or embryo survival.

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Dairy

Absorption Of Colostral Immunoglobulins By Newborn Calves

L. J. Bush and M. B. Mungle

An experiment designed to quantify the relationship between immunoglobulin (Ig) intake and level of passive immunity attained in calves during early life is nearing completion. To date, data has been obtained on 26 calves. Three separate batches of pooled colostrum having different concentrations of Ig are being fed at two levels to different calves. In addition to determination of total blood serum Ig, specific fractions of the Ig are to be measured.

Another phase of the same project involves an examination of factors affecting Ig level in colostrum. Serial samples of colostrum taken immediately after parturition are being used for this analysis.

Methods of Processing Grain for Lactating Dairy Cows

B. J. Steevens and L. J. Bush

The importance of processing sorghum grain to the extent of breaking the kernels by grinding or rolling has been well established; however, the most optimum particle size has not been clearly defined. Therefore, the first part of this experiment is concerned with grinding sorghum grain (milo) for lactating dairy cows. A 50:50 ratio of concentrate to hay was fed to 36 Holstein and Ayrshire cows with the concentrate portion consisting of 70 percent milo. The milo was ground to the various degrees of fineness as follows: (a) very fine, (b) fine and (c) medium.

The response criteria were total milk production and composition, rumen volatile fatty acids, body weight changes and apparent digestibility of the major components of the ration. All data except the starch digestibility of the ration have been collected and are currently being prepared for analysis with the aid of the computer. The grain ration was

of a fine consistency but all cows readily consumed their allotted portion. Milk production was maintained at a high level and the composition was normal for the respective breeds. Sample analysis will be completed shortly after which comparative results will be available.

A later portion of the experiment involves feeding lactating dairy cows micronized sorghum grain to see if this is an advantageaus processing method with respect to milk yield and composition and ration digestibility.

The Effect of Rate of Freezing on Sperm Cell Characteristics

Mark Hodson, Steven Fancy and Milton Wells

Freezing sperm cells in liquid nitrogen (−320°F) is the usual method used to store and maintain cells for extended periods of time. This freezing process causes the death of a high percentage (30 percent-60 percent) of sperm cells. This loss is compensated for by starting with sufficient cells to assure adequate numbers for fertilization in the delivered ampule.

A study is underway to determine the effect of rate of freezing on sperm cell characteristics, particularly, the integrity of the acrosome. Approximately 45 ejaculates from six bulls are being subjected to rates of freezing varying from extremely slow, .25-.50°C per minute, to extremely fast, 15-20°C per minute, with the control rate, 3-5°C per minute, being that currently generally recommended as being the most desirable way to freeze bull sperm cells.

Preliminary results to date indicate that the rate of freezing can definitely affect the condition of the acrosome. The excessively slow rate and the excessively fast rate seem to be the most harmful to cells. This study will be completed this year and complete analyses of the data should reveal the most desirable way to freeze semen. The results should yield information on ways to decrease losses of cells in the freezing process and thereby increase the utilization of the sperm cell production capacity of our highly desirable bulls.

Yeast Cultivation

J. B. Mickle and N. S. Knight

As the world's population continues to grow, it's logical to expect additional pressures on the animal industry for waste disposal. At present, over 14 billion pounds of whey are produced in the United States each year. Less than 30 percent of this is used and the remaining 70 percent is dumped.

Processing whey directly into animal feeds is not entirely satisfactory since the high lactose content often upsets the animals' digestive system. However, this milk sugar (lactose) can be converted into suitable nutrients by yeast and in the process most of biological oxygen demand of the whey is used. Yeast can use a variety of carbon sources, thus it also can be grown on animal wastes. However, the experimental work with whey and sewage substrates is fragmentary and there is much left to be done before this process can have wide commercial acceptance.

Algae have been grown on sewage at a cost of ½ cent a pound. Thus it would appear that there might be a market for yeast grown

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on animal wastes to be used as a protein feed supplement since the amino acid composition of certain yeasts fit the minimum requirements of a protein supplement for some animals.

The research at O.S.U. is aimed at finding yeast strains which will produce the amount of fat and protein necessary for an animal feed supplement and finding an efficient way of cultivating these. Presently, three yeast strains are being used as pure cultures. It is anticipated that other organisms will be tried in the future and an effort will be made to find groups of organisms which grow well together.

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