1978

ANIMAL SCIENCE RESEARCH REPORT

Beef and Dairy Cattle, Swine, Sheep, Poultry and their Products

AGRICULTURAL EXPERIMENT STATION
OKLAHOMA STATE UNIVERSITY
and USDA

CONTENTS

Major Articles

COW-CALF and STOCKER

Stocker and Finishing Programs for Fall-Weaned Calves ---------- 1
T. L. Mader, G.W. Horn, S. L. Armbruster, L. E. Walters, D. T. Hoskins, F. P. Horn, W. E. McMurphy and O. L. Walker

Effect of Monensin on Forage Intake and Weight Gains of Wheat Pasture Stockers ---------- 11
G. W. Horn, S. L. Armbruster, M. L. Scott and V. L. Stevens

Effect of Monensin on Forage Intake and Rumen Turnover Rate ---------- 15
R. P. Lemenager, F. N. Owens, E. L. Ferrell, D. B. Belcher, M. Dvorak, B. J. Shockey, K. S. Lusby and R. Totusek

Slow Ammonia Release for Steers ---------- 22
K. L. Mizwicki, F. N. Owens, K. Poling and G. Burnett

Range Studies With A New Slow Release Urea Compound ---------- 25
O. Forero, F. N. Owens, P. Leme and K. S. Lusby

Feather Meal As A Protein Source For Range Cows ---------- 31
P. Leme, O. Forero, F. N. Owens and K. S. Lusby

Effects of Creep Feeding on Preweaning and Postweaning Performance of Angus x Hereford Calves ---------- 35
G. L. Crosthwait, L. D. Ridenour, R. D. Wyatt, L. Knori and R. Totusek

Effects of Two Milk Levels on Preweaning Performance of Two Calf Types ---------- 40
K. C. Barnes, R. D. Wyatt, K. S. Lusby and R. Totusek

Supplemental Abomasal Nutrients for Cattle Fed Weathered Prairie Hay ---------- 44
A. B. Johnson, F. N. Owens, R. W. Fent, K. L. Mizwicki and B. R. Wilson

Ammonium Hydroxide Treatment of Wheat Straw ---------- 47
S. G. Solaiman, G. W. Horn, F. N. Owens and A. R. Rider

Stocker Bloat on Wheat Pasture ---------- 54
D. F. Frost, G. W. Horn, L. I. Croy and G. L. Burnett

Plant Chemical Composition and Digestibility of Rangeland Forage ---------- 60
R. Ball, D. G. Wagner, J. Powell and R. W. Hammond

Effect of Forage Density on Grazing Behavior, Forage Intake and Animal Performance ---------- 63
S. W. Coleman and F. P. Horn

FEEDLOT

Rumensin and Digestibility of Feedlot Rations ---------------- 70
J. H. Thornton, F. N. Owens and R. W. Fent

Buffers and High Moisture Corn Digestion ------------------- 72
J. H. Thornton, F. N. Owens, R. W. Fent and K. Poling

Influence of Endosperm Type on the Nutritive Value of Grain Sorghum and Corn ------------------------- 77
C. A. Hibberd, R. Schemm and D. G. Wagner

Seed Characteristics of Different Sorghum Endosperm Types -------- 82
B. Ackerson, R. Schemm and D. G. Wagner

Protein Levels and Decline for Finishing Steers Fed High Moisture Corn ------------------------- 87
J. J. Martin, F. N. Owens, D. R. Gill, J. H. Thornton and D. E. Williams

Rumensin Levels for Finishing Steers Fed High Moisture Corn ------ 92
D. R. Gill, F. N. Owens, J. J. Martin, J. H. Thornton and D. E. Williams

BEEF CATTLE BREEDING

Carcass Evaluation of Certain Two-Breed Cross Steers ----------- 98
M. E. Body, R. R. Frahm, L. E. Walters and L. Kimbrell

Performance to Weaning of Three-Breed Cross Calves Sired by Red Poll and Shorthorn Bulls --------------------- 103
C. G. Belcher, R. R. Frahm, L. W. Knori and E. N. Bennett

Productivity of Two-Year-Old Crossbred Cows Producing Three-Breed Cross Calves ---------------------- 105
C. G. Belcher, R. R. Frahm, L. W. Knori and E. N. Bennett

A Comparison of Profitability of Two-Year-Old Crossbred Cows ---- 111
R. L. Hintz and R. R. Frahm

SWINE

A Preliminary Comparison of the Productivity of Females of Duroc, Yorkshire, Landrace and Spot Breeding -------------- 117
R. K. Johnson, S. D. Welty, R. Vencl and J. Schooley

Growth and Carcass Traits for Pigs of Four Swine Breeds and Their Crosses ------------------------- 120
E. R. Wilson, R. K. Johnson, L. E. Walters, S. D. Welty and J. Schooley

Age and Weight at Puberty for Purebred and Crossbred Gilts of Four Breeds ---------------------------- 126
L. K. Hutchens, R. K. Johnson, S. D. Welty and J. Schooley

Protein and Choline Levels for Gestating Gilts --------------- 131
C. Maxwell, R. K. Johnson and R. Vencl

SHEEP

Rearing Orphan Lambs By Using Adoption Stalls ------------ 136
J. V. Whiteman and J. Fields

Comparison of Feed Efficiency for Two Weight Intervals and Carcass Composition at Two Market Weights of Ram and Ewe Lambs ---------------------------- 140
R. D. Herriman, R. L. Adams, L. E. Walters, J. V. Whiteman and J. E. Fields

Corn Silage Additives -------------------------------- 146
S. R. Rust, F. N. Owens, A. B. Johnson, B. J. Shockey and K. Poling

Winter and Fall Lambing Performance of Crossbred Ewes of Finnsheep, Dorset, Rambouillet and White Face Western Breeding When Mated to Purebred or Crossbred Rams ------------ 150
J. M. Dzakuma, D. L. Thomas, J. E. Fields and J. V. Whiteman

DAIRY NUTRITION and MANAGEMENT

Profile of DHI Management Factors of Twenty High and Low Producing Holstein Herds ------------------------ 156
J. D. Stout

Chemical Preservation of Alfalfa Hay for Lactating Dairy Cows ----- 160
S. A. Jafri, L. J. Bush and G. D. Adams

Effect of Prepartum Antibiotic Infusion on Mastitis Infection in Dairy Cows at First Calving ---------------------- 164
P. B. Barto, L. J. Bush and G. D. Adams

DAIRY PRODUCTS

Frozen Concentrated Cultures of *Kluyveromyces fragilis* ----------- 169
M. Bostian and S. E. Gilliland

POULTRY NUTRITION

Efficiency of Utilization of Dietary Phosphorus By Caged Turkey Breeder Hens When Fed Rations Supplemented With Live Yeast Culture ---------------------------- 173
R. H. Thayer, R. F. Burkitt, R. D. Morrison and E. E. Murray

MEAT AND CARCASS EVALUATION

A Review of Trends in Ground Beef Production -------------- 182
P. A. Will and R. L. Henrickson

Mechanical Tenderization of Electrically Stimulated Muscle -------- 189
M. Raccach and R. L. Henrickson

The Storage Stability of Electrically Stimulated Hot Boned Refrigerated Ground Beef ------------------------ 195
M. Raccach and R. L. Henrickson

The Effect of Hot Muscle Boning on Lean Yield, Cooler Space Requirements, Cooling Energy Requirements, and Retail Value of the Bovine Carcass — 200
R. D. Noble and R. L. Henrickson

Changes in the Activity of Certain Muscle Glycolytic and Oxidative Enzymes During Feedlot Growth in Cattle — 205
J. J. Guenther, J. R. Escoubas and K. K. Novotny

Growth Rate and Carcass Characteristics of Hereford Steers and Hemicastrate-SS Bulls — 208
R. P. Wettemann, L. W. Brock, R. W. Fent and D. G. Wagner

Muscle Fiber Count Per Tissue Slice by Photomicrographic and Coulter Counter Techniques — 211
J. J. Guenther and R. V. Felber

REPRODUCTIVE PHYSIOLOGY

Response of Cows to Repeated Treatments With PMS — 215
E. J. Turman, R. P. Wettemann and J. G. MaGee

Endocrine Changes Associated With Heat Stress of Gilts After Breeding — 219
D. L. Dreider, R. P. Wettemann, R. K. Johnson and E. J. Turman

The Influence of Thaw Temperature on Bovine Spermatazoa Commercially Frozen in Straws — 226
G. J. Yott and M. E. Wells

Influence of Cooling Methods on Boar Fertility with Summer Breeding — 230
R. P. Wettemann, M. E. Wells, R. K. Johnson and R. Vencl

The Influence of Radiant Heat Load and Temperature Stress on Bull Growth and Fertility — 233
D. C. Meyerhoeffer and S. W. Coleman

Summary Reports
DAIRY PRODUCTS

A Rapid Screening Test for Hydrogen Peroxide Production by Lactobacilli — 237
D. R. Martin and S. E. Gilliland

MEAT and CARCASS EVALUATION

Conditions Associated With Net K^{40} Counting Using Animal Phantoms — 239
D. D. Johnson, L. E. Walters, R. R. Frahm
R. D. Morrison and B. Lambert

The Effect of Electrical Stimulation on ATP Depletion and pH Decline in Delay Chilled Bovine Muscle — 242
P. A. Will and R. L. Henrickson

RESEARCH PERSONNEL ---------------------- 244

ACKNOWLEDGEMENTS ---------------------- 247

TABLE OF EQUIVALENTS ---------------Inside Back Cover

COW-CALF and STOCKER

Stocker and Finishing Programs For Fall-Weaned Calves

T. L. Mader, G. W. Horn, S. L. Armbruster, L. E. Walters, D. T. Hoskins, F. P. Horn, W. E. McMurphy and O. L. Walker

Story in Brief

Studies were conducted to compare live and carcass weight gains and feed efficiencies of fall-weaned steer calves (1) placed directly in the feedlot or (2) carried as stockers on wheat pasture or bermudagrass hay (stocker phase) before being finished by feeding grain on small grains-interseeded bermudagrass (SG/B) pastures or by *ad libitum* feeding in drylot. Steers from each of the two stocker programs were also grazed to heavier weights on SG/B pastures for about 60 days before being finished in drylot. Live and carcass weight gains of steers grazed on wheat pasture were 1.88 and 1.33 lb/day, respectively. Live weights of steers fed bermudagrass hay during the stocker phase were only maintained, whereas carcass gains were −0.09 lb/day. The finishing phase performance of the steers fed bermudagrass hay was, however, very good. Feed consumption of steers finished by feeding grain on pasture was high, about 80 percent of that of paired drylot, *ad libitum*-fed groups. Live and carcass weight gains of steers fed on SG/B pastures were less than those of paired drylot groups fed an equivalent amount of feed. Steers fed on SG/B pastures required an estimated 0.75 lb of additional feed dry matter for the daily gains as compared with steers fed in drylot.

Introduction

In an effort to obtain greater returns to apply against increasing cow maintenance costs, cow-calf producers may elect to retain ownership of their weaned calves through the stocker and possibly feedlot phases of production. Often producers, in face of insufficient or no forage from wheat pasture, have to make decisions on other methods of carrying fall-weaned calves through the stocker phase of production. Cattle performance on optional stocker programs and its effect on subsequent feedlot performance are key questions.

In cooperation with USDA, Science and Education Administration, Southern Region.

Finishing cattle by feeding grain on pasture is a frequently suggested alternative beef production system. The relative contributions of forage and grain to beef weight gains is an important consideration in evaluating the efficiency of finishing cattle by feeding grain on pasture.

The objectives of the studies reported herein were to:

1. Compare live and carcass weight gains of fall-weaned steer calves placed (1) directly in the feedlot or (2) on the following two stocker programs:
    A. Grazed on clean-tilled wheat pasture.
    B. Held on dormant bermudagrass pastures and fed bermudagrass hay *ad libitum*.
2. Compare the performance of steers from the above two stocker programs when grazed to heavier weights on small grains-interseeded bermudagrass pastures before being finished in drylot.
3. Determine the relative energy contributions from forage and grain to weight gains of steers fed grain *ad libitum* on small grains-interseeded bermudagrass pastures.
4. Develop enterprise budgets for each beef production system, and conduct break-even analyses for alternative price and gain relationships.

Experimental Procedure

Cattle

One-hundred and thirty-five (135) fall-weaned Hereford X Angus steer calves were purchased through an order buyer. After being carried through a receiving program of about 3 weeks, during which the calves grazed native tall grass pastures, the calves were randomly allotted to the treatment groups shown in Figure 1.

Initial feedlot group

Twelve steers (6 pens of 2 head/pen) were placed in drylot and fed *ad libitum* a finishing ration of whole shelled corn, cottonseed hulls, and supplement. The ration contained 40 percent cottonseed hulls initially, and corn was substituted for the hulls at a rate of about 1 percent per day until the steers were on a ration of 87 percent whole shelled corn, 5 percent cottonseed hulls, and 8 percent supplement. The supplement contained 60 percent crude protein on a dry matter basis.

Stocker phase

Fifty-seven (57) and 55 of the remaining steers were placed on (1) wheat pasture or (2) a dormant bermudagrass pasture and fed bermudagrass hay *ad libitum*, respectively, from November 16, 1976 to March 16, 1977. Core samples of about one-third of the bales of bermudagrass hay that were fed were

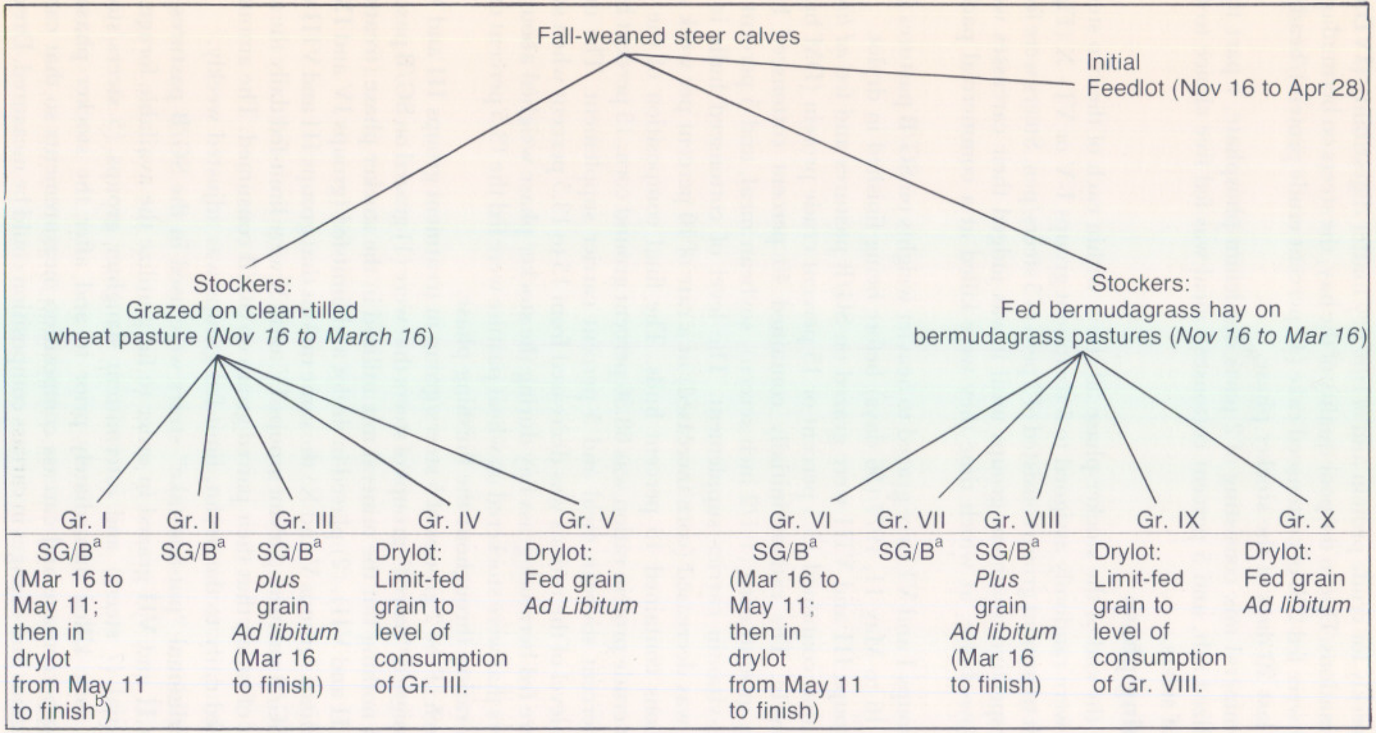

Figure 1. Steer treatment groups

[a]Small grains-interseeded bermudagrass pastures.

[b]Carcass quality of low choice.

taken weekly for crude protein and *in vitro* dry matter digestibility (IVDMD) determinations. Due to the poor quality of the hay, the steers on bermudagrass pasture were fed 2 lb of cottonseed cake (41 percent crude protein)/head/day for the last 20 days of the stocker phase.

A mineral mix consisting of 2 parts dicalcium phosphate, 1 part trace-mineralized salt, and 5 percent cottonseed meal was fed free choice to each group of steers.

Finishing phase

At the end of the stocker phase 50 steers within each of the two stocker groups were randomly assigned to 5 treatment groups I-V or VI - X (Figure 1). Each treatment group consisted of 2 pens of 5 steers/pen. Steers were fed on their respective treatment groups until it was judged their carcasses would grade low-choice, at which time they were killed at a commercial packing plant.

Groups I and VI were grazed to heavier weights on SG/B pastures from March 16 to May 11, 1977 (56 days) before being finished in drylot.

Groups III and VIII were grazed on SG/B pastures and fed *ad libitum* rations that contained 13.5 percent or 15 percent crude protein (DM basis), respectively. The rations initially contained 40 percent cottonseed hulls, coarsely ground corn (1 1/2 inch screen), soybean meal, and 5 percent of a mineral-vitamin carrier supplement. The level of cottonseed hulls in the rations was decreased (corn increased) at a rate of 10 percent per week until the rations contained 15 percent hulls. The final composition of the 13.5 percent crude protein ration was 68.56 percent ground corn, 15 percent hulls, 11.44 percent soybean meal and 5 percent carrier supplement. The crude protein level of the rations was decreased from 15 to 13.5 percent when steers that were fed bermudagrass hay during the stocker phase weighed about 650 lb. Steers that were stockered on wheat pasture were fed the 13.5 percent crude protein ration throughout the finishing phase.

Each of the 2 groups of 5 steers/group in treatment groups III and VIII were assigned "paired" groups of steers that were (1) grazed on SG/B pastures and fed nothing but the mineral mix utilized in the stocker phase (treatment groups II and VII), (2) placed in drylot and limit-fed (groups IV and IX) or fed *ad libitum* (groups V and X) the same rations that groups III and VIII were fed on SG/B pastures. Drylot groups IV and IX were limit-fed daily the same amount of ration that their paired group on SG/B consumed. The amount of ration fed daily to the drylot, limit-fed groups was adjusted weekly.

Additional "put-and-take" steers were used in the SG/B pastures that Groups II and VII grazed in order to fully utilize the available forage.

Initial (7 steers) and intermittent slaughter groups (5 steers/stocker group) were killed immediately prior to and after the stocker phase for dressing percentage and carcass composition measurements so that carcass weight gains and changes in carcass composition could be measured. Dressing percentages of the initial slaughter group, and the wheat pasture, and bermudagrass hay fed steers *after* the stocker phase were 51.78 ± 1.09 percent, 58.5 ± 1.06 percent and 49.28 ± 1.43 percent, respectively.

The small grains-interseeded (SG/B) pastures were seeded with 40 and 60 lb. of Triumph 64 wheat and Bonel rye per acre, respectively, on September 24, 1976 with a John Deere Powr-Till Seeder. Fifty pounds of nitrogen was applied per acre in early October and again in February.

All steers weights used to calculate gains were taken after overnight shrinks (usually about 16 hr) without feed and water.

Results and Discussion

Stocker phase

Weight gains of steers during the stocker phase are shown in Table 1. Live and carcass weight gains of steers grazed on wheat pasture were 1.88 and 1.33 lb/day, respectively. Live weights of steers roughed through the winter on dormant bermudagrass pastures and fed bermudagrass hay *ad libitum* were only maintained, whereas carcass weight gains were −0.09 lb/day.

Finishing phase

Live weight gains and feed efficiencies (drylot only) of steers grazed to heavier weights on SG/B pastures for 56 days after the stocker phase and before being finished in drylot are shown in Table 2. Gains of steers fed bermudagrass hay during the stocker phase were very good during the 56 days on SG/B pastures (2.21 lb/day) and while in drylot (3.53 lb/day).

The specific stocker program on which a steer has been carried prior to being placed in feedlot has long been recognized to have a substantial impact on rate of growth and efficiency of feed utilization. It is generally expected that thin feeder cattle will make compensatory gains, whereas fleshy cattle are not expected to perform as well as cattle in thin or average condition. An important question is, however, how much gains can be restricted during stocker or carry-over programs without "stunting" subsequent performance. These results indicate that gains during carry-over programs can be reduced to maintenance without precluding the ability of steers to make compensatory gains. This is also supported by the live and carcass weight gains and feed efficiencies of the drylot, *ad libitum*-fed steers from the two stocker programs (Table 3).

Gains of steers stockered on wheat pasture were significantly less ($P<.05$) during the 56 days on SG/B than those of the steers fed bermudagrass hay during the stocker phase (1.69 *vs* 2.21 lb./day), and were about 10 percent less (1.69 *vs* 1.88) than their gains on clean-tilled wheat pasture. At the end of the stocker phase, the steers coming off of wheat pasture were fairly fleshy (20.84 ± 0.96 percent estimated carcass fat versus 9.01 ± 1.12 percent carcass fat for steers fed bermudagrass hay), and probably should have been taken directly to the feedlot. The feed efficiencies of steers fed bermudagrass hay during the

Table 1. Performance of steers during stocker phase

	Wheat pasture	Bermudagrass hay[c]
Initial live wt, lb	414[a]	445[b]
Final live wt, lb	637[a]	445[b]
ADG (live), lb	1.88[a]	0.00[b]
ADG (carcass), lb	1.33[a]	−0.09[b]

[a, b]Means with different lettered superscripts are statistically different (P< .05).
[c]Mean crude protein and TDN were 7.85 ± .31 and 44.14 ± .42 percent, respectively.

Table 2. Performance of steers from two previous stocker programs when grazed on small grains-interseeded bermudagrass pastures, and then finished in drylot.

	Wheat pasture	Bermudagrass hay
Initial wt, lb	640[a]	447[b]
Final wt, lb	990	946
ADG, lb		
SG/B[c]	1.69[a]	2.21[b]
Drylot	3.28	3.53
SG/B and drylot	2.62[a]	3.08[b]
Feed/grain[d]	6.64	6.49

[a, b]Means with different lettered superscripts are statistically different (P<.05).
[c]While grazing small grains-interseeded bermudagrass pastures (56 days).
[d]Pounds feed dry matter per pound of gain.

stocker phase were slightly better (P>.05) than those of steers grazed on wheat pasture.

Live and carcass weight gains of steers fed *ad libitum* on SG/B pastures were about 78 and 84 percent, respectively, of those of their paired drylot, *ad libitum*-fed groups (Table 3). Feed consumption of steers fed grain on pasture was high — e.g., approximately 80 percent of the feed consumption of their paired drylot, *ad libitum*-fed groups. Increased maintenance energy requirements and negative associative effects of the ration that was fed and the consumed forage could account for the decreased gains of the steers fed on SG/B pastures. The combined magnitude of the possible increased maintenance energy requirements and negative associative effects, expressed as additional pounds of feed required for the observed average daily gains (bottom of Table 5), was estimated by regression analysis for each of the four groups of steers fed on SG/B pastures. Regression equations (ADG on feed intake) were calculated within each replicate, from the observed average daily gains of the drylot, (1) limit-fed and (2) *ad libitum*-fed steers, and (3) calculated daily gains for a third group of steers with feed intakes of 90 percent of the feed consumed by the steers fed on SG/B pastures. The calculated daily gains for the third group of steers, within each replicate, were multiplied by adjustment factor (Table 4 footnote C) prior to calculation of the regression equations. All calculated gains were based on the California net energy system, and ration

Table 3. Performance of steers during finishing phase

Stocker phase:	Wheat pasture					Bermudagrass hay				
Group Number:	I	II	III	IV	V	VI	VII	VIII	IX	X
Initial wt, lb[f]	640	647	641	640	638	447	445	454	447	438
Final wt, lb[f]	990		892	940	915	946		895	921	946
Hot carcass wt, lb[f]	616		549	577	573	555		537	535	563
Days fed in drylot[f]	78		108	108	92	107		163	163	154
Total days in finishing phase[f]	134	108	108	108	92	163	163	163	163	154
ADG (live), lb	2.61^{bc}	1.26^{a}	2.35^{b}	2.77^{bcd}	3.01^{cde}	3.08^{de}	1.70^{a}	2.72^{bcd}	2.92^{cde}	3.32^{e}
ADG (carcass), lb	1.80^{ab}		1.67^{a}	1.88^{ab}	2.17^{bc}	2.06^{bc}		1.93^{abc}	1.94^{abc}	2.27^{c}
Feed DM, intake, lb	21.77^{cd}		18.49^{ab}	19.20^{abc}	23.63^{d}	22.90^{d}		16.97^{a}	16.79^{a}	20.71^{bcd}
Feed/gain (live)[g]	6.64^{ab}		7.87^{c}	6.98^{bc}	7.86^{c}	6.49^{ab}		6.25^{ab}	5.74^{a}	6.29^{ab}
Feed/gain (carcass)[g]			11.05^{c}	10.24^{bc}	10.89^{c}			8.81^{ab}	8.65^{a}	9.22^{ab}

[abcde]Means with different lettered superscripts are statistically different ($P < .05$).
[f]Statistical analysis of data not compiled.
[g]Pounds feed dry matter per pound of gain.

Table 4. Calculation of adjustment factors used to adjust calculated ADGs of third group of steers

Stocker group:	Wheat pasture	Bermudagrass hay
Drylot, *ad libitum*-fed steers		
Observed ADG		
Rep. 1	3.12 (.894)[a]	3.68 (1.146)[a]
Rep. 2	2.89 (.938)	2.96 (.952)
Calculated ADG[b]		
Rep. 1	3.49	3.21
Rep. 2	3.08	3.11
Drylot, limit-fed steers		
Observed ADG		
Rep. 1	2.60 (.996)[a]	3.01 (1.176)[a]
Rep. 2	2.93 (1.291)	2.83 (1.258)
Calculated ADG[b]		
Rep. 1	2.61	2.56
Rep. 2	2.27	2.25
Calculated adjustment factors[c]		
Rep. 1	.945	1.161
Rep. 2	1.114	1.105

[a]Parenthetical numbers equal observed ADG divided by calculated ADG.
[b]Calculated for the observed feed intakes.
[c]Mean of the observed ADGs of the drylot, limit- and *ad libitum*-fed steers divided by the calculated ADGs for their observed feed intakes.

Table 5. Estimated magnitude[a] of combined increased maintenance energy requirements and negative associative effects of feeding steers on SG/B pastures.

Stocker phase:	Wheat pasture		Bermudagrass hay	
Replication:	1	2	1	2
Observed ADG, lb	2.25	2.45	2.78	2.65
Observed feed DM intake, lb/hd/day	19.18	17.79	17.68	16.26
Calculated feed DM required for observed ADGs, lb/hd/day	19.84	15.60	16.72	15.74
Observed minus calculated feed DM, lb	− 0.66	+ 2.19	+ 0.96	+ 0.52

[a]Observed feed dry matter minus calculated feed dry matter for observed ADGs.

$NE_{maintenance}$ and NE_{gain} values were reduced 10 percent since no growth-promoting implants were used in this study.

The calculations indicate that the steers grazed on wheat pasture (replication 2) or fed bermudagrass hay (replications 1 and 2) during the stocker phase, and then fed on SG/B pastures required 2.19, 0.96 and 0.52 additional pounds of feed dry matter for the observed average daily gains as compared with steers fed in drylot. A small feed-sparing effect of consumed forage is indicated by the −0.66 lb. of feed dry matter calculated for replication 1 of the steers stockered on wheat pasture.

Table 6. Steer carcass characteristics

Stocker phase:	Wheat pasture				Bermudagrass hay			
Group Numbers:	I	III	IV	V	VI	VIII	IX	X
Dressing %	62.18^{c}	62.07^{c}	61.33^{bc}	62.68^{c}	58.63^{a}	59.93^{ab}	58.09^{a}	59.48^{a}
Fat thickness, in	.84^{ab}	.78^{a}	.79^{a}	.86^{ab}	.98^{bc}	.96^{bc}	.92^{abc}	1.08^{c}
REA, sq in	12.42^{d}	10.77^{bc}	11.70^{cd}	11.42^{cd}	10.11^{ab}	9.56^{a}	10.03^{ab}	9.74^{ab}
KPH fat, %	2.90	2.85	3.05	2.95	2.85	3.05	2.95	2.95
Yield grade	3.53^{a}	3.67^{a}	3.53^{a}	3.77^{a}	4.38^{b}	4.50^{b}	4.21^{b}	4.80^{b}
Conformation score^{g}		11.7^{bc}	12.1^{c}	12.1^{c}	10.4^{a}	10.8^{ab}	10.8^{ab}	11.0^{ab}
Marbling score^{h}	14.7	12.7	14.7	14.4	13.2	12.8	12.5	14.2
Quality grade^{g}	10.1	9.4	10.4	10.3	9.7	9.4	9.2	10.0

^{abcde}Means with different lettered superscripts are statistically different ($P < .05$).

^{g}12 = high choice; 10 = low choice; 8 = average good.

^{h}17 = average modest; 14 = average small; 11 = average slight.

The carcass characteristics of the steers from the different stocker and finishing programs are shown in Table 6. Steers from the various finishing programs that were fed bermudagrass hay during the stocker phase had lower dressing percentages, greater fat thicknesses, smaller ribeye areas, higher yield grades, and lower conformation scores compared to steers grazed on wheat pasture during the stocker phase.

The live weight gains of steers grazed on SG/B pastures (groups II and VII, Table 3) were calculated from weights taken at the time that their paired groups, fed on SG/B pastures (groups III and VIII) were killed. Groups II and VII steers were held on the SG/B pastures until September 29, 1977, and five of the ten steers that had been stockered on wheat pasture and which showed the greatest degree of finish were killed. The mean live weight and average daily gain (during finishing phase only) of the five steers was 916 lb and 1.12 lb/day, respectively. Carcass quality grade of the steers ranged from low- to average-good. The steers had grazed SG/B pastures for 197 days, and had been on forage (stocker and finishing phases) for 316 days.

Performance and carcass data of the steers that were initially placed in feedlot (November 16, 1976) versus that of steers stockered on wheat pasture or bermudagrass hay prior to being finished by feeding *ad libitum* in drylot (groups V and X) are shown in Table 7. Carcass average daily gains (drylot only) of steers initially placed in the feedlot were lower ($P<.05$) than those of either group of steers that were carried through as stockers before being finished in drylot. Feed required per pound of gain was lower ($P>.05$) for steers initially placed in the feedlot. The average slaughter weight of 866 lb and carcass quality grade of slightly under low-choice indicate that the initial feedlot steers should have been fed a little longer. In general, the carcass characteristics of steers stockered on wheat pasture before being finished in drylot were more desirable; whereas carcass characteristics of steers fed bermudagrass hay during the stocker phase and the initial feedlot steers were similar.

Table 7. Performance and carcass data of initial feedlot steers versus steers carried through as stockers before being finished in drylot

Group:	Initial feedlot	Wheat pasture	Bermudagrass hay
Initial weight, lb[a]	412	638	438
Final weight, lb[a]	866	915	946
Days in stocker program	0	119	119
Days in drylot	163	92	154
Total number of days	163	211	273
Feed DM intake, lb	15.98	23.63	20.71
ADG (live), lb	2.78	3.01	3.32*
ADG (carcass), lb	1.86	2.17*	2.27*
Feed/gain (live), lb[b]	5.71	7.86	6.29
Feed/gain (carcass), lb[b]	8.53	10.89	9.22
Hot carcass weight, lb[a]	516	573	563
Dressing %	59.64	62.68*	59.48
Fat thickness, in	.93	.86*	1.08*
REA, sq in	9.75	11.42*	9.74
KPH fat, %	3.29	2.95*	2.95*
Yield grade	4.33	3.77*	4.80*
Conformation score[c]	11.4	12.1*	11.0
Marbling score[d]	13.4	14.4	14.2
Quality grade[c]	9.7	10.3*	10.0

*Significantly different from drylot group ($P<.05$).
[a]Statistical analysis on data not compiled.
[b]Pounds feed dry matter per pound of gain.
[c]12 = high choice; 10 = low choice; 8 = average good.
[d]17 = average modest; 14 = average small; 11 = average slight.

Effect of Monensin on Forage Intake And Weight Gains of Wheat Pasture Stockers

G. W. Horn, S. L. Armbruster, M. L. Scott and V. L. Stevens

Story in Brief

Wheat forage intakes of steers grazed on wheat pasture and bolused with either 0 or 200 mg. of monensin/head/day were not significantly different (P>.05), and were very similar when expressed as pounds of forage dry matter per 100 lb of body weight. Weight gains of wheat pasture stockers were decreased from 1.67 to 1.23 lb/head/day (P<.005), and increased from 0.66 to 0.70 lb/head/day (P>.05) in two field trials where stockers received 200 (hand-fed) or 36 mg (fed in molasses-mineral blocks) of monensin/head/day, respectively. A significant interaction between monensin and type of implant was not observed (P>.46) in heifers grazed on wheat pasture.

Introduction

We reported in this report last year results of studies relative to the effect of Rumensin (Elanco trade name for monensin sodium) on (1) ruminal fermentation and (2) forage intakes of wheat pasture stockers. The forage intake data represented only the first period of a switchback trial. Cooperative field trials relative to the effect of monensin on weight gains of wheat pasture stockers were underway, but no data were available at the publication deadline for last years report. This report presents the forage intake data for both periods of the switchback trial, and the results of the cooperative field trials.

Experimental Procedure

Forage intake trial

Eight crossbred steer calves (500 lb) that grazed a single wheat pasture were utilized in a switchback design. Chromic oxide was used as an indigestible marker to estimate fecal outputs. Wheat forage intakes were calculated by dividing the fecal outputs by the estimated *in vivo* indigestibilities of hand-clipped forage samples taken during each period of the trial. *In vivo* forage digestibilities were estimated from *in vitro* dry matter digestibilities according to the relationship of Oh, Baumgardt and Scholl. All steers were bolused with four grams of chromic oxide in gelatin capsules twice daily (8:00 am and 4:00 pm) for a 7-day preliminary period and a 5-day fecal collection period during which rectal fecal samples were taken each time the steers were bolused with chromic oxide. During each period of the trial one-half of the steers received 200 mg of monensin added to the chromic oxide capsules given at the morning dosage. Period I of the trial was conducted during November 17 to 28, 1976. Due to a less than optimal amount of available wheat forage shortly after the completion of period I, the steers were removed from wheat pasture and were not put back on wheat pasture until February 10, 1977. Period II of the intake trial was conducted during March 14 to 25, 1977, after the steers had had 32 days to re-adapt to wheat forage.

Effect of monensin on stocker weight gains

Two cooperative field trials were conducted as follows:

Trial 1. One-hundred and three (103) 500 lb Hereford X Angus and Hereford steers were randomly assigned to two separate wheat pastures and were fed 2 lb/head/day of a pelleted feed* that contained either 0 or 200 mg of monensin per 2 lb. The stocking rate was 1 steer/1.95 acres of wheat pasture. Both groups of steers had free access to a native range pasture located adjacent to each of the wheat pastures, and were fed large roll-bales of cheaty wheat hay on a free-choice basis during the 83-day trial (December 4, 1976 to February 26, 1977). Individual steer initial and final, shrunk live weights (overnight stand without feed or water) were measured. Since the two wheat pastures were different in size and were located about one mile apart, it was not possible to rotate the two groups of stockers among the two pastures during the trial.

The pelleted feed containing monensin was sampled four times during the trial for monensin assay, and contained 99.7, 94.9, 96.4 and 109.9 mg of monensin per lb (calculated = 100 mg monensin/lb).

Trial 2. One-hundred and twenty (120) heifers (average initial weight of 360 lb) were randomly assigned to two treatment groups, and were fed *ad libitum* molasses-mineral blocks produced by the A.E. Staley Mfg. Co. of Decatur, Illinois that contained either 0 or 400 mg monensin per pound of block for a 120-day period (November 15, 1976 to March 15, 1977). One-fourth of the heifers in each of the two groups were either not implanted with anything, or implanted with 15 mg of diethylstilbestrol (DES), 1 tube of Synovex-H, or 36 mg of Ralgro. All heifers were vaccinated for blackleg, malignant edema, leptospirosis (5 strains), treated for internal parasites with an injectable wormer, and treated for lice and grubs with a pour-on material.

Stocking rate was 1 heifer per 1.75 to 2.50 acres of wheat pasture, and the two groups of heifers were rotated among the two adjacent wheat pastures at 2-week intervals. Wheat forage growth was hampered during the first eighty days of the trial due to dry conditions and cold temperatures.

The molasses-mineral blocks were weighed four times during the trial so that block consumption could be calculated.

---

*58 percent grd. milo, 29 percent wheat middlings, 5 percent limestone, 7.5 percent molasses, 0.5 percent trace-mineralized salt.

Results and Discussion

Forage intake trial

Wheat forage intakes of steers bolused with either 0 or 200 mg monensin/head/day were not significantly different (P>.05), and were very similar when expressed as lb dry matter/100 lb of body weight (Table 1). The forage intakes during period II appear high. The steers were off of wheat pasture and grazed a dry, native grass pasture for 76 days between periods I and II during which time they only maintained their body weight. However, the average daily gain of all steers during a 30-day period from the beginning of the period II intake trial was 3.35 ± .23 lb.

Effect of monensin on stocker weight gains

Trial 1. Weight gains of stockers fed 200 mg monensin per day were decreased by 26 percent (P<.005; Table 2). Although wheat forage growth was restricted in the fall due to abnormally cold and dry weather, available wheat forage was not greatly restricted during the trial as evidenced by the performance of the control steers. An explanation for the reduced weight gains of the monensin-fed steers is not apparent since (1) differences in the amount of available wheat forage among the two wheat pastures were not discernible from visual observations made several times during the trial, and (2) since forage intakes of steers bolused with either 0 or 200 mg monensin per day were very similar in the forage intake trials. If 200 mg monensin/head/day does decrease forage intakes of wheat pasture stockers, whether or not forage intakes of steers *bolused* with monensin (as opposed to *feeding* monensin where it might be orally sensed) would be decreased may be a point of contention.

Table 1. Effect of monensin on forage intakes of wheat pasture stockers

	Control	Monensin[a]
DM/steer/day, lb		
Period I	13.3 ± 0.8	15.1 ± 1.1
Period II	22.6 ±0.9	21.8 ±2.0
DM/100 lb body wt, lb		
Period I	3.00 ± 0.14	3.03 ± 0.21
Period II	4.15 ± 0.12	4.10 ± 0.21

[a]200 mg/head/day.

Table 2. Effect of monensin on weight gains of wheat pasture stockers — Trial 1[a]

Monensin level, mg/hd/day:	0	200
Number of steers:	43	60
Average daily gain, lb:	1.67 ± .05	1.23* ± .05

[a]Cooperative Field Trial: December 4, 1976 to February 26, 1977 (83 days) Garber, Oklahoma.
*(P<.005).

Additional wheat forage intake studies where monensin is *fed* to stockers are being conducted to clarify this point.

Trial 2. Block consumption of heifers grazed on wheat pasture is shown in Table 3. Monensin consumption varied from 28 to 44 mg/head/day (average equaled only 36 mg/head/day).

Available wheat forage was limiting during the trial as evidenced by the low average daily gains (Table 4). None of the differences among the average daily gains of the eight groups of heifers (top of Table 4) were statistically significant (P>.05) although weight gains varied from 0.57 to 0.81 lb/head/day. A significant interaction between level of monensin and implant was not observed (P>.46). In contrast to the negative weight gain response to monensin observed in Trial 1, weight gains (pooled across implants) of heifers that consumed an average of 36 mg monensin/head/day were slightly increased (P>.35) — e.g., 0.70 versus 0.66 lb/head/day (middle of Table 4).

Table 3. Block consumption[a] of heifers grazed on wheat pasture

		Control		Monensin	
Date	Days	Lb block/ hd/day	Mg monensin/ hd/day	Lb block/ hd/day	Mg monensin/ hd/day
11/15-12/22/76	37	.08	0	.09	36
12/22-1/26/77	35	.10	0	.11	44
1/26-2/23/77	28	.21	0	.09	36
2/23-3/15/77	20	.13	0	.07	28
Average:		.13	0	.09	36

[a]Control and monensin-containing blocks contained 0 and 400 mg of monensin per 1 lb of block, respectively.

Table 4. Weight gains of heifers grazed on wheat pasture*

	Control				Monensin			
	No implant	DES	Synovex-H	Ralgro	No implant	DES	Synovex-H	Ralgro
ADG (n=15)	.57[a]	.67[a]	.72[a]	.69[a]	.58[a]	.81[a]	.76[a]	.66[a]

	Control	Monensin
ADG (n=60)	.66[a]	.70[a]

	No implant	DES	Synovex-H	Ralgro
ADG (n=30)	.57	.74[b]	.74[b]	.67

*Cooperative Field Trial, November 15, 1976 to March 15, 1977 (120 days) Dill City, Oklahoma.
[a]Average daily gains (lb/head/day). Means with a common lettered superscript in a horizontal row are not statistically different (P>.05).
[b]Significantly different from mean of "no implant" (P<.05).

Implanting with DES or Synovex-H (bottom of Table 4) significantly increased heifer weight gains by about 30 percent (P<.05). Weight gains of Ralgro-implanted heifers were increased about 18 percent (P>.05).

At this date (January 17, 1978) monensin is *not* presently cleared by the FDA for use in stocker programs. However, the average daily gains of stockers grazed on low- to average-quality pastures (such as native bluestem and shortgrass pastures, and bermudagrass pastures throughout the summer) have been increased by about one-quarter of a pound/head/day by feeding monensin in experimental trials. Percentage increases in stocker weight gains on these types of pastures have ranged from 11 to 39 percent.

On the basis of the two field trials that we have conducted to date, the potential of monensin for increasing weight gains of wheat pasture stockers appears uncertain. Additional trials relative to the effect of monensin onweight gains of wheat pasture stockers are presently being conducted.

Literature Cited

Oh, Baumgardt and Scholl. 1966. J Dairy Sci. *49*:850.

Effect of Monensin on Forage Intake and Ruman Turnover Rate

R.P. Lemenager, F.N. Owens, E.L. Ferrell, D.R. Belcher, M. Dvorak, B.J. Shockey, K.S. Lusby and R. Totusek

Story in Brief

Two trials were conducted to evaluate the effect of monensin on forage intake, rumen turnover rates, 24 hr volatile fatty acid patterns and rumen nitrogen components of cattle consuming low quality dry native range grass. In Trial 1 cows were fed a 30 percent protein soybean meal supplement with 0, 50 or 200 mg of monensin per cow per day. In Trial 2, mature ruminally cannulated steers were fed the same supplement with 0 or 200 mg of monensin. A third trial was conducted to estimate rumen turnover rate and cellulose disappearance rate of steers fed a high concentrate diet at a rate to meet maintenance requirements with 0, 50, 100 or 200 mg of monensin per steer daily.

Cow weight change was similar when 200 mg of monensin was added to the control supplement in Trial 1. However, cows fed the 50 mg level lost more weight than either the control or 200 mg monensin treatments. Relative forage intake, in Trial 1, was reduced 13.6 and 19.6 percent when 50 and 200 mg of monensin were fed respectively and was reduced 16 percent, in Trial 2, when 200 mg of monensin was fed.

Liquid rumen turnover rates were reduced 31 percent in Trial 2 and 10 percent in Trial 3 when 200 mg of monensin was fed. Solid rumen turnover rates were 44 percent slower in Trial 2 with 200 mg. Monensin also shifted the volatile fatty acid patterns of steers in favor of propionic acid without affecting cellulose disappearance or rumen nitrogen components.

Introduction

Monensin increases the energy content of the diet by increasing the ratio of propionate to acetate and butyrate. Forage fed cattle generally eat to bulk fill; therefore, an increase in usable energy by shifting the VFA's should result in increased weight gain or reduced weight loss. Monensin has been shown to reduce feed intake of cattle consuming high quality forage and concentrate rations, but little attention has been given to forage intake of cows fed near maintenance rations.

The relationships between fermentation rate, turnover rate and extent of digestion indicate the importance of turnover rate in the economy of feed utilization by the ruminant. The most complete digestion of forages will be obtained with a long rumen retention time (slow turnover rate). However, in some cases a short rumen retention time and reduced digestibility may result in more total energy intake.

The effect of monensin on rumen turnover rate and its relationship with feed intake has not been examined; therefore, the purposes of this study were: 1) to evaluate the effect of monensin on forage intake of cattle consuming low quality dry winter range grass, 2) to evaluate the effect of monensin on ruminal turnover rate of steers fed low quality harvested dry winter range grass or an 80 percent concentrate diet fed to meet maintenance requirements and 3) to evaluate the effect of monensin on ruminal nitrogen components and cellulose disappearance.

Procedure

Trial 1

Sixty-nine mature open Hereford cows were employed in a 123 day trial from November 13 to March 15. Cows were randomly allotted by weight to 23 simultaneous 3 × 3 Latin squares. The three treatments were 0, 50 or 200 mg of additions of monensin per cow daily to 30 percent natural crude protein supplements. Ingredient make-up of the supplement is shown in Table 1. All cows were allowed to graze native tallgrass range with climax vegetation of little bluestem, big bluestem, Indian grass and switch grass. Cows were corralled six days per week and individually stall fed 2.75 lb of their respective supplement once daily.

Cows were weighed at the beginning and end of each 41 day period. On the last day of each period, cows were fed their respective supplements and allowed to graze for approximately 3 hours, after which rumen samples were taken for VFA analysis.

Relative forage intake of cows grazing dry native winter range grass was estimated in December, February and March using chromic oxide (20 gm/head/day). The chromic oxide was administered with one-half the daily allocation of supplement at 8 am and 4 pm during the six day preliminary and five day fecal collection periods. Fecal grab samples were dried at 140 F and analyzed for chromium content, lignin, cellulose and acid detergent fiber. Representative forage samples were also obtained, using three esophageally cannulated cows, to estimate forage digestibility.

Trial 2

Eight mature, ruminally cannulated steers weighing approximately 1,375 lb were randomly allotted to two treatments in a cross-over design. A 30 percent protein soybean meal supplement (Table 1) was fed with or without 200 mg of monensin added per steer daily. Steers were individually housed in slatted floor pens and *ad libitum* fed low quality winter range grass harvested in late December. Grass was chopped to a maximum length of five inches. Grass intake was recorded daily.

Steers were adapted to their respective supplements for a period of 13 days prior to measuring turnover rate. Liquid and solid rumen turnover rates were estimated by using polyethylene glycol and chromic oxide respectively. On day 13 of each period 50 gm PEG and 20 gm chromix oxide were mixed and fed at 8 am the daily allocation of supplement. Rumen samples were obtained at 4, 10, 16 and 22 hr post-supplement feeding and centrifuged to separate solid and liquid fractions. The liquid fraction was analyzed for PEG and for volatile fatty acids while the solid fraction was dried at 212 F for 48 hr and analyzed for chromium. Peptide nitrogen was determined on the 4 and 22 hr liquid fraction while alpha-amino nitrogen was estimated on the 22 hr liquid fraction only.

Trial 3

Four mature, ruminally cannulated Holstein steers were randomly assigned to four treatments in a Latin square design with 0, 50, 100 and 200 mg of monensin per steer per day. A high concentrate diet was limit-fed to meet maintenance requirements. The ration (Table 2) was fed twice daily at 8 am and 4 pm at a rate of 5.98 lb per feeding.

Steers were adapted to their respective supplements for two weeks. On day 9 and 13 of each period, steers were dosed intraruminally with 50 gm of

Table 1. Ingredient makeup of protein supplement

Item	International reference number	% in supplement
Corn, yellow	4-02-915	22.77
Soybean meal	5-04-604	58.25
Alfalfa hay, grd	1-99-118	10.00
Molasses, cane	4-04-696	5.00
Sodium phosphate, monobasic	6-04-287	2.50
Calcium phosphate, dibasic	6-01-080	.75
Sodium sulfate	6-04-292	.68
Trace mineral mix		.05
Vitamin A palmitate	7-05-143	22,000 IU/kg

Table 2. Ingredient makeup of ration in Trial 2

Item	International Reference No.	5 in Supplement
Corn, yellow	4-02-935	62.75
Soybean meal	5-04-604	10.00
Alfalfa, dehy	1-00-022	6.00
Molasses, cane	4-04-696	5.00
Cotton seed hulls	1-01-599	14.00
Urea		.10
Ammonium chloride		.50
Limestone		.50
Calcium phosphate, dibasic	6-01-080	.50
Trace mineralized salt		.50
Aurafac - 10		.15

chromium EDTA, to measure liquid rumen turnover rates and sampled at 4 and 24 hr after dosing. Samples were centrifuged and the liquid fraction analyzed for chromium content.

Cellulose disappearance rate was estimated using unwashed, unsized cotton fiber strips. On day 9 and 13 of each period these cotton fiber strips were suspended in the rumen for 24 hr, recovered, washed, dried and weighed to determine cellulose degradation.

Results and Discussion

Trial 1

Performance of cows grazing dry winter range grass is shown in Table 3. Average daily supplement intakes were equal among treatments. Weight loss of cows fed the 0 and 200 mg monensin supplements were similar. Cows fed the 50 mg of monensin lost significantly more weight than cows on the other treatments. These results would suggest that 50 mg is less useful than 0 or 200 mg of monensin per day for cows grazing poor quality winter range.

Table 3. Performance and relative forage intake of cows during winter supplementation in Trial 1

	Monensin, mg/cow/day		
Item	0	50	200
Cows, number	69	69	69
Daily supplement, lb	2.75	2.75	2.75
Initial cow wt, lb	901.52	898.50	899.60
Cow wt change, lb	=14.87[a]	−21.47[b]	−14.15[a]
Forage intake, lb	21.14[a]	18.26[b]	17.01[c]

a,b,cMeans with different superscripts are significantly different (P<.05).

Table 4. Total and molar percentages of volatile fatty acids in rumen fluid of cows in Trial 1

	Monensin, mg/cow/day		
Item	0	50	200
Acetate, molar %	78.46[a]	78.43[a]	73.68[b]
Propionate, molar %	15.86[b]	16.85[b]	21.92[a]
Butyrate, molar %	5.71[a]	4.70[b]	4.12[c]
Total mM/1	32.11	31.77	30.42

a,b,cMeans with different superscripts are significantly different (P<.05).

Relative forage dry matter intakes are shown in Table 3. Forage intake was significantly depressed 13.6 percent with 50 mg of monensin and 19.6 percent with 200 mg of monensin when compared to the control treatment. The estimated forage digestibilities were 41.7, 38.2 and 39.8 percent for December, February and March intake trials respectively.

Total and molar percentages of volatile fatty acids are shown in Table 4. Rumen fluid from cows fed the 200 mg supplement had less acetate and butyrate and more propionate than rumen fluid from cows fed the control supplement. Rumen fluid from cows fed the 50 mg supplement was intermediate in concentration of VFA's between the control and 200 mg treatments, but not consistently different from the control. The failure of the 50 mg level of monensin to consistently alter acetate, propionate and butyrate further indicates it is not the proper level of monensin for cows grazing dry native winter range. Total molar concentration of VFA's was not significantly affected by the addition of monensin.

Trial 2

When monensin was fed, average daily forage intakes (Table 5) were significantly depressed by 15.6 percent. These results closely agree with those of cows in Trial 1. A partial explanation for decreased feed intake with monensin feeding may be that rumen digestion, solid turnover and liquid turnover rates were decreased when monensin was fed. Steers fed monensin had a 30.8 percent slower liquid turnover rate and a 43.6 percent slower solid rumen turnover rate than control steers. Decreased turnover matches the reduction in feed intake with monensin supplementation of high roughage rations.

Table 5. Intake, rumen turnover and rumen volume of steers fed harvested dry winter range grass in Trial 1

Item	Monensin, mg/steer/day	
	0	200
Intake, lb	10.12[a]	8.54[b]
Liquid turnover, dilution %/hr	6.53[c]	4.52[d]
Solid turnover, dilution %/hr	2.73[c]	1.54[d]

[a,b]Means with different superscripts are statistically different ($P<.02$).
[c,d]Means with different superscripts are statistically different ($P<.10$).

Table 6. Twenty-four hour volatile fatty acid pattern of steer fed harvested dry winter range grass in Trial 1

Item	Monensin, mg/steer/day	
	0	200
4 hr sampling		
Acetate, molar %	68.50[a]	63.40[b]
Propionate, molar %	25.56[b]	30.48[a]
Butyrate, molar %	5.95	6.12
Total, mM/1	41.54	44.95
10 hr sampling		
Acetate	73.00[c]	64.14[d]
Propionate, molar %	20.20[c]	29.27[d]
Butyrate, molar %	6.80	6.59
Total, mM/1	46.45[e]	33.05[f]
16 hr sampling		
Acetate, molar %	76.09[c]	63.89[d]
Propionate, molar %	17.96[d]	30.02[c]
Butyrate, molar %	5.96	6.08
Total, mM/1	45.71	41.74
22 hr sampling		
Acetate, molar %	72.56[e]	66.54[f]
Propionate, molar %	21.10[f]	27.15[e]
Butyrate, molar %	6.33	6.31
Total, mM/1	45.78[a]	35.63[b]

[a,b]Means with different superscripts are significantly different ($P<.10$).
[c,d]Means with different superscripts are significantly different ($P<.001$).
[e,f]Means with different superscripts are significantly different ($P<.05$).

Twenty-four hour volatile fatty acid patterns of steers fed harvested dry winter range grass is shown in Table 6. Acetate was significantly decreased and propionate significantly increased when monensin was fed at the 4, 10, 16 and 22 hr samplings. Butyrate was not significantly affected by monensin at any sampling time. Total VFA concentration was lower at the 4 and 16 hr samplings when monensin was fed.

Nitrogen components of liquid rumen contents from steers fed harvested dry winter range grass are shown in Table 7. Peptide nitrogen was not significantly affected at either the 4 or 22 hr sampling by the addition of monensin. These data suggest that monensin did not cause free amino acid or

Table 7. Liquid rumen nitrogen components of steers fed harvested dry winter range grass in Trial 1

Item	Monensin, mg/steer/day 0	200	S.E.
4 hr sampling[1]			
Peptide nitrogen, mg/m1	2.72	3.04	.25
22 hr sampling[2]			
Peptide nitrogen, mg/m1	4.07	3.73	.56
α-amino nitrogen, mM	4.35	4.50	.46

[1]Sampled 4 hr post-supplement feeding.
[2]Sampled 22 hr post-supplement feeding

Table 8. Cellulose disappearance and liquid rumen turnover of steers limit fed a high concentrate ration in Trial 2

Item	Monensin, mg/steer/day 0	50	100	200
Cellulose disappearance rate, %	18.8	15.9	13.6	19.1
Liquid turnover, dilution %/hr	5.33[a]	4.82[ab]	4.78[ab]	4.16[b]
Rumen liquid volume, 1	53.0	67.8	58.0	65.9

[a,b]Means with different superscripts are statistically different ($P<.05$).

peptide nitrogen accumulation in the rumen of cattle fed low quality dry winter range grass.

Trial 3

In vivo cellulose disappearance and liquid rumen turnover rates of steers limit-fed a high concentrate ration are shown in Table 8. *In vivo* cellulose disappearance rate was not significantly altered when monensin was added to the control supplement, however, it appears that the 50 and 100 mg levels of monensin may slightly depress cellulose digestibility on a high concentrate ration. Turnover rates of rumen liquid tended to be slower in the 50, 100 and 200 mg of monensin treatments than the control with an apparent linear depression as monensin level increased. These results agree with those obtained in Trial 1.

Several theories exist that may explain the relationship between reduced forage intake and rumen turnover rate when monensin is fed. First, rumen turnover rate may be decreased because intake is decreased. In Trial 2, with steers *ad libitum* fed harvested low quality range grass, rumen turnover rate was slower. This may be the result of reduced intake. However in Trial 3, with steers limit-fed a high concentrate diet, intake of feed was held constant while turnover rate declined. This suggests that the second theory may explain the forage intake and rumen turnover rate relationship; reduced rumen turnover rate causes a reduction in forage intake. It appears that monensin depresses rumen turnover rate independent of its effect on intake as shown in Trial 3. Consequently, the depression in rumen turnover appears independent, and therefore probably the cause and not simply a result of reduced forage intake.

Based on research finding to date, it seems that monensin decreases intake of low quality forages as well as rumen turnover rate. One explanation for reduced forage intake is decreased rate, but not necessarily extent of ruminal digestion. Decreasing the rate of digestion of particulate matter in the rumen would prolong rumen retention and slow rumen turnover. Reduced rumen turnover would decrease feed intake if bulk fill limits intake. The decreased energy intake of monensin fed cattle may not reduce performance however, due to compensating factors. These may include: 1) increased propionate production, 2) decreased methane production, 3) decreased heat loss, 4) decreased energy expenditure for grazing and 5) decreased metabolic fecal energy loss.

Slow Ammonia Release for Steers

K. L. Mizwicki, F. N. Owens,
K. Poling and G. Burnett

Story in Brief

Slow and rapid ruminal ammonia release rates were simulated by feeding urea intermittently. Steers were fed half a pound of prairie hay hourly with the following daily dietary supplements: Urea continuously (C) as 0.007 lb/hr; moderate (M) as 0.031 lb/hr for 6 hr; rapidly (R) as 0.19 lb of urea in 1 hr, or no supplemental urea (0). Ruminal ammonia remained stable with treatments C and O. Treatments R and M peaked at 1.5 and 6.5 hr after feeding began showing that slow release of ammonia was effectively achieved. Digestibility of dry matter was increased by 5 percent and retention of nitrogen was increased with the addition of urea regardless of the rate of urea administration. Simulated slow ammonia release rates enhanced neither dry matter digestibility nor nitrogen retention. Use of ammonia in the rumen was not improved by slowing its release rate.

Introduction

Cattle grazing low quality forage utilize supplemental urea poorly. This has been attributed to rapid breakdown of urea to ammonia with low availability of energy for bacteria to use the ammonia. Slowing the ammonia release rate might help balance ammonia and energy availability. The objective of this study was to determine if slow release of ammonia would prove beneficial for digestion and nitrogen retention of steers fed winter range grass.

Experimental Procedure

Four 790 lb crossbred steers were held in metabolism stalls and fed hourly with timed automatic feeders. Winter harvested native prairie hay was fed at a rate of ½ lb/hr. Daily nitrogen supplements provided urea continuously (C) as .007 lb urea/hr for 24 hr each day; moderated (M) .031 lb urea/hr for 6 hr each day; rapidly (R) .19 lb urea in the first hour, or no supplemental urea (0). In addition, 1.33 lb of an energy supplement (Table 1) was provided the first hour of each 24 hr feeding cycle similar to commercial supplementation practices for cattle grazing winter range. Steers were rotated among treatments so that each steer received each treatment for 2 weeks. Total urine and feces were collected the last 5 days of each period.

Results and Discussion

Ruminal ammonia concentrations over time with each treatment are shown in Figure 1. These patterns generally reflect infusion times and should simulate rapid, slow or very slow release compounds or no supplemental urea.

Table 1. Diet composition

Ingredients	Energy supplement	Urea supplement
	%	%
Corn, dent, yellow grain, ground	74.7	----
Urea	----	62.1
Alfalfa, aerial part, dehy. meal	18.4	----
Sodium sulfate	2.88	----
Monosodium phosphate	3.31	----
Sugarcane, molasses, dehy.	----	37.9
Salt, trace mineralized	.61	----
Vitamin Premix[a]	.062	----

[a]To provide 2200 IU Vitamin A/kg and 275 IU D_3/kg feed.

Digestibilities (DMD) for the ration and for cellulose were increased by urea feeding (Table 2). Timing of urea feeding, however, did not influence digestibility. The increase in DMD is attributable completely to an 8 percent increase in cellulose digestibility with urea addition.

Nitrogen digestibilities were increased from 13 to 60 percent with the addition of urea. Protein digestibilities, recalculated assuming that urea was completely digestible, show a decrease in digestibility of non-urea nitrogen from 13 percent with no additional urea to 4 percent with additional urea (Table 2). This decrease in protein digestibility may be attributed to use of urea nitrogen for bacterial protein synthesis. Such bacterial protein would

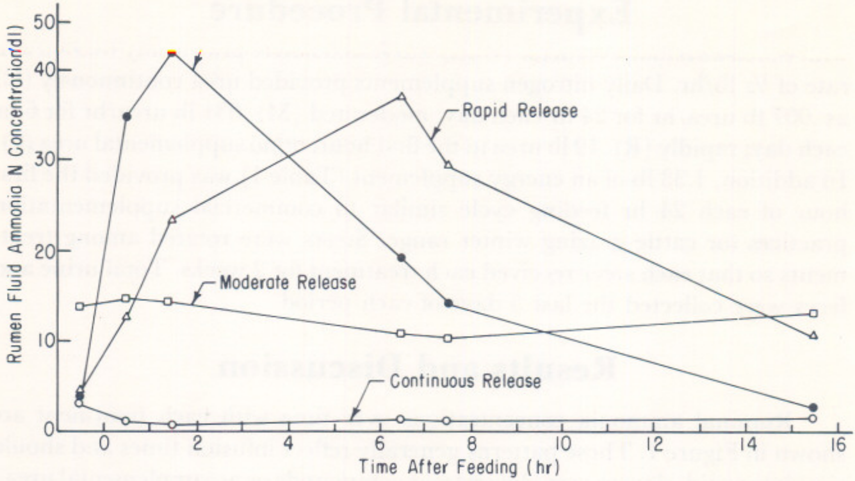

Figure 1. Ruminal ammonia concentrations with interval urea supplementation. Treatments are no urea (●), Rapid release (△), Moderate release (□) and Continuous release (○).

Table 2. Digestibility of nutrients by steers receiving urea at various intervals

Item	Urea administration interval				
	No Urea	Rapid	Moderated	Continuous	SE[a]
			%		
Dry matter[b]	46.8	48.8	50.0	48.9	.88
Cellulose[b]	50.8	54.3	55.4	55.4	1.39
Nitrogen[c]	13.4	60.2	60.3	60.3	1.44
Nitrogen adjusted[c,d]	13.4	3.4	3.0	5.6	1.46

[a]Standard error of the mean.
[b]Mean of urea treatments differs statistically from no urea (P<.05).
[c]Mean of urea treatments differs statistically from no urea (P<.01).
[d]Calculated assuming complete digestion of urea.

have a digestibility of about 66 percent, lower than the 100 percent assumed in the above calculation. Steers fed urea had greater nitrogen retention than those fed no urea independent of the rate of release of ammonia (Table 3).

Slow release of ammonia did not improve digestibility, nitrogen balance or ruminal protein synthesis in this experiment with steers fed a limited amount of low quality forage. Perhaps under free choice feeding conditions feed intake could favor slow ammonia release. But the benefit of slow release compounds with low quality forages remains to be proven. Enhanced feed intake and decreased "ammonia intoxication" may be responsible for im-

Table 3. Nitrogen retention by steers receiving urea at various intervals

Item	No Urea	Urea administration interval			SE[a]
		Rapid	Moderate	Continuous	
Nitrogen intake, g/day[b]	23.2	60.4	60.2	60.4	.80
Nitrogen excretion, g/day					
Fecal[c]	20.7	24.0	23.7	24.2	.86
Urinary[b]	9.8	25.1	24.3	23.9	1.86
Nitrogen retention, g/day[b]	−7.1	11.4	12.2	12.4	1.58

[a]Standard error of the mean.
[b]Mean of urea treatments differs statistically from no urea ($P<.01$).
[c]Mean of urea treatments differs statistically from no urea ($P<.05$).

proved performance of range cows fed the slow release compound discussed elsewhere in this report.

Range Studies With A New Slow Release Urea Compound

O. Forero, F. N. Owens, P. Leme and K. S. Lusby

Story in Brief

A new slow release urea compound (SRU) which had previously been shown to attenuate ruminal ammonia release and reduce the potential for urea toxicity was evaluated in range supplements in two wintering trials. Seventy-eight pregnant Hereford cows were fed 2 lb/head/day of supplements with 15 or 40 percent all natural protein, 40 percent protein supplements with SRU furnishing 62.5 percent of the protein equivalent (one SRU supplement was pelleted, one was fed in meal form) and a 40 percent protein supplement in which urea furnished 62.5 percent of the protein equivalent. Weight changes for the 60-day trial were 9.9, 66.3, 59.0, 57.9 and 13.8 lb for the 15 and 40 percent all natural, 40 percent SRU (pellet and meal) and urea respectively. In a second wintering study, 85 lactating Hereford cows were individually fed five supplements consisting of 2.7 lb/head/day of 15 and 40 percent all natural protein, 40 percent protein (SRU meal form), 40 percent protein (urea) and a

20 percent protein supplement with urea but fed at twice the rate as the 40 percent supplements. Supplements were fed six times each week with all cows grazing a common pasture. Cow weight changes for the 92-day period were: −198.4, −78.6, −151.1, −172.1 and −172.0 for 15 and 40 percent all natural, 40 percent SRU, 40 percent urea and 20 percent urea supplements, respectively. Calf gains followed the same trend as cow weight changes with calves of SRU cows gaining significantly more than calves of urea or 15 percent natural protein fed cows. Calf gains for these groups were 78.3, 101.2, 88.1, 74.5 and 73.4, respectively. Improved palatibility of urea in the SRU form was evident with the individually fed cows. No SRU or natural protein supplements were refused while cows fed urea supplements consumed only about 61 percent of their supplement. Rebreeding performance was poorest for 15 percent natural fed cows and highest for 40 percent natural with urea and SRU cows intermediate. Samples of rumen fluid showed that SRU produced a ruminal ammonia level at one hour after feeding similar to that of soybean meal. Ammonia peaks of the urea supplements were 2 to 2.5 fold that of SRU at 1 hr.

Introduction

Urea has probably been as extensively researched as any other known feedstuff. Even so, a satisfactory urea compound for feeding to ruminants consuming high roughage diets is still unknown. One problem with urea is the rapid hydrolysis of urea to ammonia in the rumen producing excess ammonia shortly after feeding with toxicity being a well known consequence of a overfeeding error involving urea supplements. A new commercially prepared slow release urea compound (SRU), developed by NIPAK Corporation was shown in laboratory and metabolism studies to produce a slow, sustained release of ammonia in the rumen. Further SRU was shown to be much safer than urea in a toxicity study with steers.

The objective of these trials was to evaluate winter performance of pregnant and lactating Hereford cows when fed SRU, urea and natural protein supplements.

Materials and Methods

Range cow trials

Seventy-eight mature pregnant and 85 mature lactating Hereford cows were used in two winter trials on native tallgrass range in Central Oklahoma. Little bluestem (*Andropogon scoparious*), big bluestem (*Andropogon gerardi*), Indian grass (*Sorgastrum nutans*) and switch grass (*Panicum virgatum*) were the principal forage species.

Pregnant cows were randomized by weight and group-fed five supplemental protein treatments, (1) 15 percent natural protein (negative control), pelleted, (2) 40 percent natural protein (positive control), pelleted, (3) 40 percent crude protein, 62.5 percent of the crude protein equivalent from SRU, pelleted, (4) same as 3 except fed in meal form and (5) 40 percent crude protein, 62.5 percent of the crude protein equivalent from prilled urea. Supplement compositions are shown in Table 1. Supplements were fed in bunks at the rate of 2 lb/head/day prorated for feeding 6 days per week. Cows were rotated bi-weekly among five pastures of approximately 120 acres each. The wintering period extended 60 days from November 15 to January 14.

Lactating cows were randomized by weight and individually fed five supplements in covered stalls. All individually fed cows were grazed in a single pasture and gathered at 8 am, 6 days per week for supplement feeding. Supplemental treatments and pounds of supplement per head per day were (1) 15 percent natural protein (negative control), 2.7 lb, (2) 40 percent natural protein (positive control), 2.7 lb, (3) 40 percent crude protein, 62.5 percent of the crude protein equivalent from SRU, 2.7 lb (4) 40 percent crude protein, 62.5 percent of the crude protein equivalent from urea, 2.7 lb and (5) 20 percent crude protein, 62 percent of the crude protein equivalent from urea fed at twice the rate of supplement 4 so that both 4 and 5 were isonitrogenous but 5 contained twice the energy of 4.

Individually fed cows were visually scored for degree of fatness at the beginning and end of the experimental period (November 15 - February 15). A scale of 1-10 was used with 1 equal to very thin to 10 being very fat.

All cows were weighed after overnight shrink away from feed and water. Calves of the individually fed cows were weighed at the end of the trial period following 6 hr separation from their dams. Samples of ruminal fluid from individually fed cows were drawn for ammonia analysis at 1 and 4 hr after supplement feeding in mid-January.

Individually fed cows were artifically inseminated for a 30-day period (January 2 - February 1) and exposed to a bull for a further 15 days (February 2 - February 17). Estrus was detected using chin-ball markers with sterile teaser bulls during the artifical insemination period and with breeding bulls during the subsequent period. Pregnancy was determined by rectal palpation approximately 60 days after termination of the breeding season.

Results and Discussion

In range studies with pregnant cows SRU was fed in either meal or pelleted supplements to evaluate the effects of pelleting damage to the coating on performance of cows. The trial was terminated in mid-January due to drought conditions which made equal forage availability across pastures impossible after late January.

No feed refusals were noted for any of the supplements during the trial (Table 2). Cows fed the 40 percent protein soybean meal supplement gained more ($P<.05$) weight than cows fed 15 percent protein supplement. Weight gains of cows fed SRU in meal or pellet form performed identically, suggesting

Table 1. Ration compositions

Ingredient	40% natural protein	15% natural protein	40% crude protein (SRU)	40% crude protein (prilled urea)	20% crude protein (prilled urea)
Corn, rolled		53.80	43.30	43.60	69.50
Alfalfa hay, ground	5.00	15.00	15.00	15.00	7.50
Cottonseed hulls	5.00	10.00			11.00
Soybean meal	85.25	16.90	19.10	19.40	
Cane molasses			6.00	7.00	4.00
Salt, trace mineralized					
Limestone					
Dicalcium phosphate	.50	.89	1.00	1.00	1.00
NaH_2PO_4	2.20	2.70	2.70	2.70	1.35
Na/SO_4	2.10	.75	2.35	2.35	1.17
Trace mineral premix	.05	.05	.05	.05	.05
Urea				8.90	4.50
Slow release urea			10.50		
Vitamin A (30,000 IU/gm) 7-05-143	.12	.12	.12	.12	.12

Table 2. Weight changes, pregnant cows, group fed

Protein source	Soybean meal		SRU		Urea
Protein level, %	15	40	40	40	40
Form of supp	pellet	pellet	pellet	meal	pellet
No. of cows	15	16	16	15	16
Supp intake, lb	2	2	2	2	2
Cow wt change, lb (60 days)	9.9[b]	66.3[a]	59.0[a]	57.9[a]	13.8[b]

[a, b]Means on a line with the same superscript letter do not differ ($P<.05$).

that coating damage during pelleting did not affect cow performance. Both SRU groups gained slightly less than the 40 percent soybean meal fed group, indicating that SRU was well utilized by the pregnant cows. Gains of cows fed the uncoated prilled urea supplement were lower ($P<.05$) than for cows fed SRU or the positive control. The poor performance observed for prilled urea is consistent with previous work at this station (Rush and Totusek, 1975; Rush *et al.*, 1976; and Rush and Totusek, 1976).

Improved palatability of urea in the coated form was evident with the individually fed lactating cows. No feed refusals of soybean meal protein or SRU supplements were noted, whereas cows fed uncoated prilled urea consumed about .15 lb urea per day regardless of the urea (or energy) level of the supplement. Refusal of the uncoated urea supplements made comparison of urea supplements to SRU and natural protein supplements difficult since nitrogen intake was lower with the uncoated urea treatments than for the other groups. Yet results are indicative of expected animal performance from such supplements. Poor palability of urea has been widely reported.

Lactating cows fed the 40 percent protein soybean meal supplement lost less ($P<.05$) weight during the 92-day feeding period than the 15 percent protein supplement or the urea supplements (Table 3). Feeding slow release urea resulted in less weight loss ($P<.05$) than the 15 percent protein supplement, but weight loss of cows fed SRU or urea was still excessive. Cows fed the 40 percent protein soybean meal supplement also lost less condition ($P<.05$) during the 92-day period than all other treatments. Cows fed SRU tended to lose less condition ($P<.10$) than urea-fed cows, in agreement with weight loss patterns. These results suggest that while SRU may be adequate to meet the ruminal ammonia deficiency of dry pregnant cows, total protein supply remains inadequate for lactation. Satter *et al.* (1977) concluded high producing dairy cows should not be fed non-protein nitrogen during early lactation since their protein requirement greatly exceeds the potential microbial protein synthesis. Results from this study suggest a similar situation for lactating beef cows grazing low-quality low-protein forage. The fact that cows fed the 20 percent crude protein supplement lost almost the same amount of weight as cows fed the 40 percent crude protein supplement with uncoated urea rejects the hypothesis that additional energy improves urea utilization as measured by weight change under range conditions.

Of the 17 cows fed the 40 percent protein soybean meal supplement, all exhibited estrus and 16 were determined pregnant 60 days after termination of breeding. Of the cows fed 15 percent protein only 9 showed estrus and only 7 became pregnant during the same period. Among the urea treatments, higher pregnancy rates ($P<.05$) and frequencies of estrus were seen for cows fed the 40 percent crude protein supplement with uncoated urea. The higher estrus incidence and pregnancy rate for urea-fed cows is difficult to explain in view of the high and similar heavy weight losses seen with all three urea treatments. The number of days to first estrus during the breeding period was similar among all five treatments.

Calf gains were higher ($P<.05$) for calves of cows fed SRU than those of dams fed urea or the negative control, but less ($P<.05$) than gain of calves from the positive control group. This suggests that SRU may have been more effective in maintaining milk production than uncoated urea.

One hour after supplement feeding, rumen ammonia levels of cows fed SRU were slightly (non-significant) higher than for cows fed the 40 percent protein supplement containing soybean meal. Rumen ammonia levels of urea-fed cows were about 2 to 2½ times greater than for SRU-fed cows at one hour post feeding. At four hours post feeding, SRU produced rumen ammonia levels almost identical to those of the 40 percent protein soybean meal supplement but higher ($P<.05$) than for the 15 percent protein supplement. Urea supplement tended to produce higher levels of rumen ammonia than SRU at 4

Table 3. Cow and calf performance, individually fed cows

Protein source	Soybean meal		SRU		Urea
Protein level, %	15	40	40	40	20
Supp intake lb/day	2.7	2.7	2.7	1.6	3.4
Cow wt, initial, lb	946	946	942	944	935
Total wt loss, lb (92 days)	-192.4^{c}	-78.6^{a}	-151.1^{b}	-172.1^{b}	-172.0^{b}
Total calf gain, lb	78.3^{c}	101.2^{a}	88.1^{b}	74.5^{c}	73.4^{c}
Cow condition change[1]	−3.5	−1.6	−3.0	−3.3	−3.4
Cows showing estrus	9^{c}	17^{a}	12^{bc}	15^{ab}	10^{bc}
Cows pregnant[2]	7^{b}	16^{a}	8^{b}	13^{ab}	9^{b}
Rumen ammmonia,					
Mg %, 1 hr post feeding	4.8^{a}	6.2^{ab}	10.4^{b}	25.0^{d}	18.3^{c}
Mg %, 4 hr post feeding	2.7^{a}	7.2^{b}	7.3^{b}	10.3^{b}	9.2^{b}

a, b, c, d Means on a line with the same superscript letter do not differ ($P<.05$).
[1]Scale: 1 = very thin-10 = very fat.
[2]Determined by rectal palpation 60 days after breeding season.

hr post feeding also, showing that SRU did indeed slow the hydrolysis of urea in the rumen.

These results, along with previous studies with SRU (Lusby *et al.*, 1977) show that SRU does reduce the rate of urea hydrolysis, reduce toxicity and improve palatibility of urea in feeds. However the mechanism for improved animal performance seen in these two trials is not completely understood. Results of simulated slow release by Mizwicki *et al.*, (elsewhere in this publication) suggest that slow ammonia release does not improve dry matter intake or digestibility of this type roughage. If this were the case with the range trials as well, the improved performance seen with SRU may have been the result of greater and more uniform nitrogen intake or possibly alleviation of subclinical ammonia toxicity from the high ruminal ammonia peaks seen with urea. Further work is continuing.

Literature Cited

Lusby, K. S., F. N. Owens, K. Mizwicki and O. Forero. 1977. Coated urea for ruminants. Abstracts of 69 annual meeting, American Society of Animal Science, Madison, Wisconsin, p. 246.

Rush, Ivan G. and Robert Totusek. 1975. Effects of frequency of injection of high urea winter supplements by range cows. J. Anim. Sci. 41:1141.

Rush, Ivan G., R. R. Johnson and Robert Totusek. 1976. Evaluation of beef cattle range supplements containing urea and biuret. J. Anim. Sci. 42:1297.

Rush, Ivan G. and Robert Totusek. 1976. Supplemental value of feed grade biuret and urea-molasses for cows on dry winter grass. J. Anim. Sci. 42:297.

Satter, L. D.; L. W. Whitlow and G. L. Beardsley. 1977. Resistance of protein to rumen degradation and its significance to the dairy cow. Distiller's Fed. Res. Council. 32:63.

Feather Meal As A Protein Source For Range Cows

P. Leme, O. Forero, F. N. Owens and K. S. Lusby

Story in Brief

Hydrolyzed feather meal (HFM), a treated by-product of the poultry industry was compared to soybean meal as a protein source for 64 dry, pregnant beef cows grazing dormant, native range in winter. Feather meal furnished approximately one-half the protein in supplements containing 15 or 40 percent crude protein. The trial was conducted for 85 days from November 15, 1976 to February 8, 1977. Cows were group-fed in bunks and rotated among pastures at 2-week intervals. Weight gains were similar for HFM and soybean meal supplements although HFM fed cows tended to gain more than soybean meal fed cows at the 15 percent protein level and less than soybean meal fed cows at the 40 percent protein level. Some palatability problems were encountered at the highest HFM level with 2 of 16 cows in that group refusing to eat supplement. Gain differences between 40 percent and 15 percent protein levels were highly significant, indicating that protein was limiting in this study. Weight gains between HFM and soybean meal supplemented groups were similar although HFM produced a glossier hair coat than soybean meal.

Introduction

The high cost of the traditional plant proteins for cattle supplements has stimulated much research into alternative protein sources. Unfortunately years of research with NPN and other substitutes have not produced satisfactory results.

One possible source of protein for cattle feeds which has not been extensively utilized is hydrolyzed feather meal (HFM), a by-product of the poultry processing industry. Poultry feathers are approximately 80-90 percent keratin, an indigestible protein which becomes relatively well digested when treated with pressure and steam heat (hydrolyzed). The resulting product is a dark meal with excellent pelleting properties. Feather meal is widely used in poultry and swine feeds as a source of cystine. Limited research has also shown HFM to be a good replacement for plant proteins in sheep, dairy and steer supplements. If cows grazing dormant native range could utilize protein from HFM efficiently, HFM could potentially lower the cost of winter supplementation for Oklahoma producers.

The objective of this trial was to evaluate the performance of beef cows fed protein supplements in which HFM replaced approximately one-half the protein supplied by soybean meal.

Materials and Methods

Sixty-four dry, pregnant Hereford cows were randomized into four supplemental protein treatments. Supplements fed were 15 or 40 percent crude protein with either soybean meal of HFM and fed at the rate of 2 lb/head/day prorated for feeding 6 days per week. Supplement compositions are shown in Table 1. Feather meal was calculated to provide about one-half the crude protein in one 15 percent and one 40 percent protein supplement. All supplements were fed as ¼-inch pellets and fed in bunks allowing 3.7 ft of bunk space per cow. Cows grazed dormant native range grass with no hay fed during the trial which lasted from November 15, 1976 to February 8, 1977. Initial, final and 28-day intermediate weights were taken after overnight shrink without feed or water. Cows were rotated among pastures at 14-day intervals.

Ruminal fluid was sampled by stomach tube two days after termination of the study. On the day of sampling, supplements were fed to cows of each group so that all cows were sampled at approximately 1 hr after supplement was consumed.

Results and Discussion

Cow weight gains were greater ($P<.05$) for both 40 percent protein supplements than for 15 percent supplements indicating that protein was limiting during the trial (Table 2). Gains of cows fed HFM supplements were not significantly different from gains of cows fed soybean meal supplements at the 15 percent protein level although cows fed HFM at the 40 percent protein level gained less ($P<.05$) weight when compared to soybean meal at the 40 percent protein level. A possible explanation for the reduced gains by HFM supplemented cows at the 40 percent protein level could be palatability of a supplement containing 29 percent feather meal. Two cows refused to eat this

Table 1. Supplement composition (air dry basis)

	Supplements			
	15% CP	15% CP	40%	40%
Ingredients (%)	Soy	HFM	Soy	HFM
Rolled corn	53.8	62.9	- - -	22.6
Molasses		5.0	- - -	5.0
Ground alfalfa hay	15.0	15.0	5.0	15.0
Cottonseed hulls	10.0	5.0	5.0	- - -
NaH_2PO_4	2.7	2.5	2.2	2.5
Dicalcium phosphate	.8	.8	.5	.8
$NaSO_4$	.8	.7	2.0	1.8
Trace mineral mix	.05	.05	.05	.05
Hydrolyzed feather meal		8.0	- - -	29.4
Soybean meal	16.9	- - -	85.3	22.8
% crude protein, actual	13.4	15.2	41.5	34.6

Table 2. Cow weight changes and rumen ammonia levels

	Supplements			
	15% CP Soy	15% CP HFM	40% CP Soy	40% CP HFM
No. of cows	16	16	16	16
Supp, lb/day	2	2	2	2
Total wt gain, lb	1.0[c]	17.1[c]	61.8[a]	38.4[b]
Rumen ammonia, Mg/100 ml	5.0[c]	6.0[bc]	6.5[b]	10.6[a]

[a, b, c]Means in a line with the same superscript letter do not differ ($P<.05$).

supplement and were removed from the study after about two weeks. Although the 14 cows remaining on the 40 percent HFM treatment consumed all their supplement each day, weight changes within this group tended to be more variable than within the 40 percent soybean meal fed cows suggesting a more erratic intake of the HFM. The 15 percent protein supplement with HFM was readily consumed. Rakes *et al.* (1968) reported that dairy cows sometimes refused to eat when HFM was abruptly added to their concentrates although results of the present range study indicate that palatibility should not be a problem if the level of HFM is relatively low. The HFM used in this study was lower in crude protein (74 percent CP) than anticipated from book values. This resulted in the 40 percent HFM supplement being about 5 percent lower in CP than the calculated value of 40 percent. The fact that high HFM supplement contained approximately 5 percent less protein than the 40 percent supplement with soybean meal could partially explain the advantage in cow weight gain seen with the 40 percent protein soybean meal supplement.

It was noted that haircoats of HFM supplemented cows tended to be glossier than haircoats of soybean meal fed cows. This could possibly be the result of the high sulfur amino acid content of HFM.

Ruminal ammonia levels (Table 2) were higher for cows fed both 40 percent protein supplements, as expected. However, both 15 and 40 percent protein supplements with HFM produced higher ammonia levels than the respective soybean meal supplements. This was surprising since most reports show feather meal to be less soluble in rumen fluid than soybean meal. (Thomas and Beeson, 1977).

Since data from this study as well as studies with dairy cattle, lambs and steers have shown that HFM can replace a portion of plant proteins in supplements, the critical factor in determining the usefulness of HFM will be cost. The December 26, 1977 F.O.B. Kansas City price for HFM was \$232.50/ton compared to \$173.00/ton for soybean meal (source, Feedstuffs). These prices convert to a cost of 14.5¢/lb crude protein for HFM containing 80 percent crude protein and 19.7¢/lb for crude protein for soybean meal (44 percent). This is a savings of 26.4 percent per pound of protein in favor of HFM. This study indicated that HFM could be used to reduce supplemental protein costs for cows grazing native range without any great effect on cow weight change. Producers should, however, avoid sudden changes to supplements containing high levels of HFM since this change can result in feed refusals by some cows.

Literature Cited

Rakes, A. H., D. G. Davenport, J. D. Pettyjohn and A. C. L. Linnerud. 1968. Hydrolyzed feather meal as a protein source of lactating dairy cows. J. Dairy Sci. 51:1701.

Thomas, V. M. and W. M. Beeson. 1977. Feather meal and hair meal as protein sources for steer calves. J. Anim. Sci. 45:819.

Effects of Creep Feeding on Preweaning and Postweaning Performance Of Angus x Hereford Calves

G. L. Crosthwait, L. D. Ridenour, R. D. Wyatt,
L. Knori and R. Totusek

Story in Brief

The effect of creep feeding on preweaning and postweaning calf performance was determined. Forty-two Angus x Hereford calves produced by Hereford cows were allotted to either a creep or non-creep feeding program.

Creep-fed calves were 40 lb heavier at weaning and gained 0.17 lb more per day than calves not receiving creep. In addition, creep-fed calves were 0.90 inches taller and 0.47 inches longer at weaning than non-creeped calves. Creep feeding reduced forage intake by 11.70 percent but did not influence the level of milk intake.

During the postweaning feedlot phase calves which were previously creep-fed gained 6.4 percent faster and were 5.2 percent more efficient at converting feed to gain than non-creeped calves.

At slaughter, creep-fed calves were 46 lb heavier and yielded carcasses 49 lb heavier than non-creeped calves. Creep-fed calves had 0.2 inches more backfat and produced carcasses with 1.2 percent lower cutability than non-creeped calves. Other carcass characteristics were not significantly affected by creep feeding.

Introduction

The cow-calf producer trying to obtain the highest possible return per dollar invested is interested in increasing the weaning weight of his calves. Creep feeding has been shown to effectively increase the rate of gain and condition of suckling beef calves. Kuhlman *et al.* (1961) reported increased gains from creep feeding of 44 lb and Nelson *et al.* (1958) reported weight increases of 65 and 88 lb on two creep rations as compared to non-creeped calves.

No previous work at this station has been conducted to determine the effect of creep feeding on postweaning performance. This study conducted in the spring and summer of 1976 was designed to determine the effect of creep feeding on preweaning and postweaning performance and carcass traits of beef calves.

In cooperation with USDA, Science and Education Administration, Southern Region.

Materials and Methods

Forty-two Angus x Hereford calves were used to determine the effect of creep feeding vs non-creep on preweaning and postweaning feedlot performance. Calves produced by Hereford cows were allotted to either a creep or non-creep feeding program. Cow-calf pairs were managed under tallgrass native range conditions at the Southwestern Livestock and Forage Research Station (El Reno) during the spring and summer of 1976. All cows were seven-year-olds producing their sixth calf. Calves were born during December, January and February with an average calving date of January 15.

Cows received 5 lb of a 30 percent all-natural crude protein supplement five days per week post-calving. This supplement level was calculated to allow an approximate winter weight loss of 20 percent (including calving weight loss).

Creep feeding was initiated on March 2 and continued until calves were weaned at 240 ± 7 days of age. Composition of the creep ration is shown in Table 1.

Milk intake by calves was estimated at monthly intervals using the calf suckle technique. Estimates of daily milk intake represent the cumulative total milk consumed during four consecutive determinations made after 6 hr periods of separation of calves from their dams.

Forage intake of calves was estimated in August 1976, while calves were on lush native pasture. Forage intake was estimated using an external indicator technique employing chromic oxide as the indicator.

At weaning calves were fasted for 6 hr, weighed, photographed and vaccinated for blackleg, parainfluenza-3 and infectious bovine rhinotraecheitis. Calves were placed directly into the feedlot at weaning.

Skeletal size was estimated from 2″ × 2″ slides taken of each calf behind a grid at weaning and prior to slaughter. Height was defined as the distance from the hip to the floor and length as the horizontal distance from the point of the shoulder to the hip.

Table 1. Composition of creep ration

Ingredient	Percentage
Corn, ground	49.5
Alfalfa hay, chopped	15.0
Cottonseed hulls	10.0
Soybean meal (44%)	17.5
Molasses, liquid	5.0
Wheat mids	3.0
	100%

Table 2. Composition of feedlot ration

Ingredient	Percentage
Corn, rolled or ground	60.20
Cottonseed hulls	15.00
Alfalfa hay, chopped	10.00
Cottonseed meal	8.00
Molasses, blackstrap	5.00
Dicalcium phosphate	0.50
Urea	1.00
Salt	0.30
	100.00%
Chlortetracycline (Aureomycin) mg/lb	7
Vitamin A IU/lb	1000

In the feedlot, calves were fed a 75 percent concentrate diet (Table 2) *ad libitum*. Calves were divided by treatment and sex and fed in four groups.

Each calf was fed to an estimated quality grade of low choice based on subjective evaluation of apparent fatness. Final weights and photographs were taken after a 12 hr fast.

Calves were slaughtered in a commercial packing plant and chilled 72 hr before quality grade, marbling score, maturity and kidney, heart and pelvic fat were estimated by a USDA grader. Rib-eye area and backfat thickness were measured from a tracing at the 12th to 13th rib separation on each carcass. Cutability was predicted by the equation of Murphey *et al.* (1960).

Results and Discussion

Preweaning calf performance is summarized in Table 3. Creep-fed calves were 40 lb heavier ($P<.02$) at weaning than non-creeped calves. This represents an 8.9 percent increase in preweaning rate of gain.

Creep-fed calves consumed 702 lb of creep ration per head. This represents 17.8 lb of creep feed/lb of added gain.

Creep-fed calves tended to be longer ($P>.17$) and taller ($P<.02$) at weaning than non-creeped calves.

Creep-fed calves were showing more condition than non-creeped calves as evidenced by their higher ($P<.01$) weaning condition scores. Conformation score was not influenced by creep feeding.

The effect of creep feeding on forage and milk intake is shown in Table 4. Calves on creep tended ($P>.14$) to consume less forage (11.7 percent less) than non-creep calves. Milk intakes were not affected by creep feeding.

Feedlot performance of the calves is summarized in Table 5. Creep-fed calves tended to have higher average daily gains ($P>.17$) and more efficiently converted feed into gain than non-creeped calves. Creep-fed calves were heavier ($P<.02$) at slaughter than non-creep calves.

There was a trend for creep fed calves to be taller ($P>.14$) and longer ($P>.14$) at slaughter than the non-creep calves. This is consistent with trends observed for these calves at weaning.

Table 6 summarizes carcass data for the calves. The cutability of the creep-fed calves was 1.2 percent lower ($P<.03$) than non-creeped calves. This resulted from the creep-fed calves having significantly ($P<.01$) heavier carcasses and greater ($P<.02$) backfat thickness and tending ($P>.19$) to have more kidney, heart and pelvic fat, while rib-eye areas were not affected.

Non-creep-fed calves on the average had more marbling and thus graded slightly higher than creep-fed calves. However, this effect was not significant.

Economic analysis

Creep feeding is practiced with the expectation of increased profit; however, careful consideration must be given to many factors when deciding

Table 3. Preweaning performance of calves

	Creep	No Creep
Birthweight, lb	69.	68.
Weaning weight, lb[a]	565.[f]	525.[g]
Average daily gain, lb	2.07[f]	1.90[g]
Weaning height, in[b]	38.6[f]	37.7[g]
Weaning length, in[c]	28.3	27.8
Conformation grade[d]	12.3	12.0
Condition score[e]	6.0[f]	5.3[g]

[a]240-day sex corrected weaning weight. Sex correction factor of 1.05 used to adjust heifers to a steer equivalent.
[b]Height at hip.
[c]Length from point of shoulder to hop.
[d]10=average good 11=high good 12=low choice
[e]1=very thin 9=very fat
[f,g]Means with different superscripts are statistically different (P<.10).

Table 4. Forage and milk intake

	Creep	No Creep
Relative forage intake, %	88.3	100
Milk intake; day, lb	11.42	11.17

Table 5. Postweaning performance of calves

	Creep	No Creep
Average daily gain, lb	2.51	2.36
Feed conversion[a]	7.80	8.23
Feed intake, lb/day	19.56	19.37
Slaughter age, days	398	408
Slaughter weight, lb	946.82[b]	900.75[c]
Height at slaughter, in	44.07	43.31
Length at slaughter, in	30.68	29.69

[a]Pounds of feed required to produce a pound of live weight gain.
[b,c]Means with different superscripts are statistically different (P<.10).

Table 6. Carcass data

	Creep	No Creep
Cutability[a]	46.11[e]	47.33[f]
Hot carcass wt, lb	946.82[e]	900.75[f]
Rib-eye area, sq. in	10.81	10.39
Backfat thickness, in	1.01[e]	0.84[f]
Kidney, heart and pelvic fat	3.57	3.37
Quality grade[b]	6.64	7.13
Marbling[c]	10.79	11.60
Maturity[d]	1.28	1.13

[a]Calculated using Murphey's Prediction Equation.
[b]6=good plus, 7=low choice
[c]10=small minus, 11=small
[d]1=a minus maturity
[e,f]Means with different superscripts are significantly different (P<.10).

Table 7. Economic Analysis

	Creep	No Creep
Adjusted selling wts, lb	557	518
Value of calf, $	236.73	222.74
Creep-fed per calf		
Pounds	701.6	0
Cost, $	42.10	0
Value of increased gain, $	13.99	
Return of increased gain minus feed cost, $	−28.11	

whether or not to creep feed. These factors include the age and milk producing ability of the dam, season of calving, availability of pasture, the kind of creepfeed and the market outlook.

The economic analysis shown in Table 7 is based on Oklahoma 1977 prices. Different prices may be substituted as appropriate.

Several assumptions were employed in the economic analysis. Selling weights were based on a sex distribution of 50 percent steers and 50 percent heifers with a 240-day adjusted weaning weight.

The calves had an estimated value of $44.50/cwt for creep feed steers and $45.00/cwt for non-creep steers with a $5.00/cwt discount for heifers. Estimated calf value was calculated by multiplying the selling weight by their respective price/cwt and then calculating a weighted steer heifer average. A sex distribution of 60 percent steers and 40 percent heifers was assumed for calves produced for sale.

Creep-fed calves had the highest total value. However, adjustment for the extra cost involved in feeding creep removed this advantage. On the basis of return above investment the non-creep fed values were the most profitable. The economic loss due to creep feeding was −$28.11 per head.

Literature Cited

Kuhlman, L.R., 1961, Oklahoma Agri. Exp. Station MP-64:9-11.
Murphey, C.E., 1960, J. Anim. Sci. 19:1240 (Abstr.).
Nelson, A.B., 1958, Oklahoma Agri. Exp. Station MP-51:93-102.

Effects of Two Milk Levels on Preweaning Performance of Two Calf Types

K. C. Barnes, R. D. Wyatt, K. S. Lusby and R. Totusek

Story in Brief

The effect of two levels of milk intake on the pre-weaning performance by calves of two growth potentials was determined. This was accomplished by breeding Hereford cows to Angus bulls and Hereford x Holstein (crossbred) cows to Charolais x Angus bulls, followed by reciprocal cross-fostering whereby calves of each breed combination were exposed to a low (Hereford) or medium (crossbred) level of milk.

The medium level of milk consumption (16-18 lb /day, produced by Crossbreds) resulted in an additional 88 and 121 lb of weaning weight in Angus x Hereford and Charolais-Angus x Hereford-Holstein (crossbred x crossbred) calves, respectively. Increasing the level of milk consumption from 10 to 16-18 lb/day resulted in a reduction in apparent efficiency of conversion of milk to calf gain of 26 and 37 percent in Angus x Hereford and Crossbred x Crossbred calves, respectively.

Increasing the milk consumption level of calves can increase calf growth rate but the desirability of this strategy for intensification will depend on the relationship between the costs of providing higher energy and protein requirement of heavier milking cows and return from additional calf gain.

Introduction

Recent economic conditions have made it essential for the cow-calf producer to efficiently improve the productivity of his herd. To the commercial producer, this means pounds of calf available for market at the time of weaning. Selection for increased calf weaning weight usually results in an automatic selection for higher milk production in cows due to the strong positive relationship between milk production level and calf weaning weight. In recent years, there has been considerable interest in the infusion of dairy breeding into beef herds as a means of rapidly increasing the milk yield of cows and intensifying the cow-calf enterprise.

Increasing the milk production level in cows using beef-dairy crossbreeding has resulted in distinct increases in calf weaning weights. However, the effects of increased milk consumption on calf performance are not clear since the effects of increased milk level were confounded with genetic differences for growth rate potential in calves.

In cooperation with USDA, Science and Education Administration, Southern Region.

The purpose of this study was to compare the effects of two levels of milk intake on the preweaning performance of calves of two growth potentials managed under range conditions.

Materials and Methods

Twenty-three Hereford and 15 Hereford x Holstein (crossbred) cows were used to study the effects of two levels of milk intake on calves of two growth potentials. A system was employed whereby calves of similar breeding could be exposed to a low (Hereford) and medium (crossbred) level of milk consumption. This was accomplished by breeding the Hereford cows to Angus bulls and the Crossbred cows to Charolais x Angus bulls followed by reciprocal cross-fostering of about one-half of the calves at birth. Thus, within each calf breed (Angus x Hereford and Crossbred x Crossbred) one group was the recipient of a low level of milk (10 to 11 lb/day) while another group received a medium milk level (16 to 18 lb/day).

All cows were eight-year-olds producing their seventh calf. Cows were maintained on tallgrass native range and calved during December and January.

Cows received a post-calving winter supplement level considered adequate for their size and milk production level based on the results of earlier work at this station. Hereford and Crossbred cows were fed 3.0 and 6.0 lb per day, respectively, of a 30 percent all-natural crude protein supplement. These supplement levels were calculated to allow a 20 percent winter weight loss including weight loss at calving.

Parturition was induced in some cows by administration of 40 mg dexamethazone (Azium) within 10 days of their projected calving date to allow scheduling of the cross-fostering program. Calves were grafted on to foster dams within 12 hr following birth.

Forage intake trials were conducted in May and August 1977 while calves were on lush native pasture. Relative forage intake by calves was estimated by use of an external indicator technique employing chromic oxide as the indicator.

Results and Discussion

Performance of cows is summarized in Table 1. Winter weight losses were similar for both cow breeds. Calves raised on their natural dams (Angus x Hereford on Hereford cows and Crossbred x Crossbred calves on Crossbred cows) had average birth dates one to two weeks after the cross-fostered calves.

Calf performance is shown in Table 2. Angus x Hereford calves consumed 10.6 and 16.3 lb of milk daily of the low and medium milk levels, while Crossbred x Crossbred calves consumed 10.3 and 18.0 lb of milk daily at the low and medium levels, respectively. When exposed to equivalent milk levels,

Table 1. Performance of cows

Breed of dam	Hereford		Hereford x Holstein	
Breed of calf	Angus x Hereford	Crossbred x Crossbred	Angus x Hereford	Crossbred x Crossbred
Daily winter supp post-calving, lb.	3.0	3.0	6.0	6.0
Weight, Fall 1976, lb	1146	1146	1228	1257
Weight, Spring 1977, lb	930	934	988	993
Winter weight change, lb	−216	−212	−240	264
Winter weight loss, %	18.8	18.5	19.5	21.0
Calving date	1-9-77	12-31-76	12-30-76	1-14-77

Table 2. Performance of calves

Breed of calf	Angus x Hereford		Crossbred x Crossbred	
Milk intake level	Low	Med	Low	Med
Daily milk consumption, lb	10.6	16.3	10.3	18.0
Birth weight, lb	68.2	68.6	74.6	79.6
Weaning weight, lb[a]	524	612	493	614
Daily gain, lb[b]	1.91	2.22	1.72	2.22
Conformation grade[c]	12.0	13.3	10.9	12.9
Condition score[d]	5.1	6.4	4.5	4.7

[a]240-day sex corrected weaning weight. Sex correction factor of 1.05 used to adjust heifers to a steer equivalent.
[b]Rate of daily gain adjusted for birth weight.
[c]11=high good, 12=low choice, 13=average choice.
[d]1=very thin, 9=very fat.

Angus x Hereford and Crossbred x Crossbred calves consumed about the same amount of milk. Thus, it appears that the potential growth rate of calves had little affect on milk intake in this study. The range in milk consumption observed here should include levels which would be encountered under most range beef cattle production situations.

At weaning, Angus x Hereford calves consuming the medium levels of milk (16.3 lb) were 88 lb heavier than calves receiving the low milk level (10.6 lb). This represents a 17 percent increase in weaning weight or an additional .31 lb per day gain. Increased milk consumption was also reflected in condition scores (apparent fatness) of the calves. Condition scores for Angus x Hereford calves were 5.1 and 6.4 for the low and medium milk levels.

Crossbred x Crossbred calves receiving the medium level (18.0 lb) and 121 lb heavier at weaning than calves at the low level (10.3 lb). This was a 25 percent increase in weaning weight or an additional .50 lb of gain per day. Among Crossbred x Crossbred calves, the level of milk intake had little effect upon condition score. It is interesting to note that the larger Crossbred x Crossbred calves showed no advantage in growth rate when raised on equivalent milk levels with the smaller Angus x Hereford calves.

As milk consumed and rate of gain increased the apparent efficiency with which milk was utilized for gain decreased (Table 3). Angus x Hereford calves

Table 3. Milk conversion efficiency

Breed of calf	Angus x Hereford		Crossbred x Crossbred	
Milk intake level	Low	Med	Low	Med
Milk per lb gain[a], lb	5.8	7.3	6.0	8.2
Additional milk per lb additional gain, lb		18.6		25.0

[a]Gain from birth to weaning.

Table 4. Relative forage intake[a]

Breed of calf	Angus x Hereford		Crossbred x Crossbred	
Milk intake level	Low	Med	Low	Med
Trial 1 (May)	100	96	98	86
Trial 2 (August)	100	98	101	94

[a]Expressed as percent of forage intake by Angus x Hereford calves at the low milk intake level.

receiving the medium milk level required 1.5 lb more milk per pound of gain than calves on the low milk level. This represents a 26 percent decrease in the efficiency of milk utilization by calves at the high level of intake. An additional 18.6 lb of milk was required to produce one additional pound of gain above that of Angus x Hereford calves receiving the low milk level. Crossbred x Crossbred calves consuming the medium milk level required 2.2 lb more milk/lb of gain compared to calves receiving the low milk level. This represents a 37 percent decrease in efficiency of utilization compared to calves receiving the low level or an additional 25 lb of milk to produce one additional pound of weaned weight.

Forage intake by calves of the same breed combination consuming low or medium milk levels did not differ greatly, however, there was a trend toward higher forage intake by calves receiving the low milk level (Table 4). Higher forage intake levels would be expected due to the lower milk intakes of calves reared on low milk.

Supplemental Abomasal Nutrients For Cattle Fed Weathered Prairie Hay

A. B. Johnson, F. N. Owens,
R. W. Fent, K. L. Mizwicki
and B. R. Wilson

Story in Brief

To determine which nutrients limit performance of wintering cattle grazing range grass, five nutrient solutions were infused into the abomasum (the acid stomach past the rumen) of five mature Hereford steers for a period of 10 weeks. Nutrients infused were protein, carbohydrate, fat and the amino acid, methionine. Nutrient infusion did not affect intake of the 48 percent digestibility ration of winter-harvested prairie hay. Nitrogen balance, a measure of protein storage by the animal, was increased with protein but not with methionine or urea infused postruminally. Results suggest that amino acids in protein other than methionine may limit protein status of cattle fed weathered range grass. This is a post-ruminal, not a ration deficiency. But since some intact protein escapes destruction in the rumen, intact proteins such as soybean or cottonseed meal are more beneficial than non-protein nitrogen for wintering cattle.

Introduction

Low performance of cattle fed low quality forages has been associated with a shortage of energy or low feed intake. This has generally been attributed to bulk fill, although an increase in crude protein often increases feed intake and digestibility of cellulose. When protein or starch has been infused into the "true stomach" or abomasum (past the rumen), feed intake and performance of lambs fed a high concentrate (highly digestible) ration was increased.

The objectives of this experiment were to determine the effect of various nutrients abomasally infused on voluntary feed intake, dry matter and protein digestibility, and nitrogen balance (protein status) of mature steers fed weathered prairie hay.

Materials and Methods

Five mature Hereford steers fitted with permanent fistulas into their rumen and abomasum were used in this experiment. The steers had free access to winter-harvested prairie hay containing 2.3 percent crude protein and were fed 2 lb daily of a 14.3 percent crude protein supplement (Table 1). Forage intake was measured.

Nutrients infused (Table 2) included: water, dextrose, corn oil, casein (a protein) and methionine. All treatments had dextrose and urea to equalize energy and crude protein infusion. Methionine and casein provided equal amounts of the sulfur amino acids. The infusions were diluted in 1.4 gallons of water and infused continuously, 24 hr/per day.

Feces and urine were collected for 5 days in each period and analyzed for nitrogen. Blood and rumen samples were taken on the last day of collection. The blood plasma was analyzed for glucose and insulin while the rumen sample was analyzed for ammonia concentration.

Table 1. Ration supplement

Ingredient	Percentage
Rolled corn	53.6
Soybean meal	16.9
Dehydrated alfalfa	15.0
Cottonseed hulls	10.0
Monosodium phosphate	2.7
Deflourinated rock phosphate	.89
Sodium sulfate	.75
Trace minerlized salt	.05
Vitamin A (30,000 IU/g)	.12

Table 2. Abomasal nutrient infusates

Infusate treatment	Infusate composition: Dry matter (g)	Urea nitrogen (g)	Energy (kcal)
Water	----	41.2	----
Dextrose	286.2	41.2	1144.8
Oil	127.0	41.2	1143.0
Casein	286.2	----	1144.8
Methionine + dextrose	10 Methionine + 286.2 Dextrose	41.2	1144.8

Results and Discussion

Total dry matter intake was not affected by any infusion (Table 3). This supports the theory that voluntary feed intake of a high forage diet is limited by the capacity or "bulk fill" of the rumen. Other factors as exercise, pregnancy, lactation and environment also may regulate forage intake.

Protein and dry matter digestibilities (Table 3) were low and not influenced by infusion. Low dry matter digestibility may be due to a deficiency of ammonia in the rumen.

Plasma glucose concentrations (Table 4) were increased by infusions of high amounts of dextrose alone or with the methionine. Since casein produced no response in plasma, this suggests that catabolism of the protein for energy was not large. Plasma insulin (Table 4) increased with the infusion of casein. Insulin levels are 5 to 20 times higher than this in feedlot steers. Similarly low levels have been reported for ruminants not fed for 24 to 72 hr. Low insulin levels may reflect a negative energy balance for cattle.

Infusion of casein increased nitrogen retention (Table 3) over all other infusions. This suggests that amino acids in casein other than methionine limit the nitrogen status of ruminants fed a low quality roughage ration. If post-ruminal protein supply is marginal, this helps explain the superiority of intact protein over non-protein nitrogen supplements for wintered range cattle. Portions of fed soybean meal and cottonseed meal bypass the rumen undegraded and may help meet this need. Increasing post-ruminal flow of deficient amino acids or protein for wintered range cattle may prove useful.

Table 3. Intake, digestibility and ruminal ammonia of infused steers

Item	Infusate				
	Water	Dextrose	Oil	Casein	Methionine
Total dry matter intake, g/day	5008	5182	4660	5097	5301
Digestibility, %					
Dry matter	49.7	47.6	46.1	48.8	45.1
Nitrogen	66.9	65.9	65.5	66.4	64.4
Nitrogen retention g/day	17.3	19.5	16.6	29.9	16.3
Ruminal ammonia, mg %	2.99	2.00	3.7	2.85	2.82

Table 4. Plasma glucose and insulin levels of infused steers

Item	Infusate				
	Water	Dextrose	Oil	Casein	Methionine
Plasma					
Glucose, mg %	58.1	69.4	57.4	56.4	62.4
Insulin uU/ml	1.43	1.28	1.41	2.20	1.51

Ammonium Hydroxide Treatment of Wheat Straw

S. G. Solaiman, G. W. Horn,
F. N. Owens and A. R. Rider

Story in Brief

Chopped wheat straw, containing increasing amounts of added water was treated with a constant level of ammonia (3.3 percent of straw dry matter) as ammonium hydroxide, and stored for 1 to 60 days before determing *in vitro* dry matter digestibility (IVDMD), nitrogen content and fiber-bound nitrogen (ADF-N) versus free ammonia nitrogen (NH_3-N) of the treated sample. The overall improvement (e.g., mean of all day × moisture treatment combinations) in IVDMD of treated versus untreated straw was about 33 percent, whereas nitrogen content of treated straw was increased from 4.6 percent crude protein to 11.0 percent crude protein. Fiber-bound nitrogen and NH_3-N accounted for 12.6 and 43.4 percent of the retained nitrogen, respectively, when averaged across all day × moisture treatment combinations. The ammonium hydroxide treatment increased straw digestibility by (1) directly decreasing the total cell wall fiber (NDF) and hemicellulose fractions (perhaps by solubilization effects), and (2) increasing the digestibility of the NDF, hemicellulose and cellulose fiber fractions.

Introduction

An estimated 1 ton of wheat straw is available as a potential feedstuff for each acre of wheat that yields 20 to 25 bushels of grain. Both the digestibility and crude protein content of wheat straw are generally low. Chemical treatment of crop residues with various alkalis, such as sodium hydroxide, calcium hydroxide and potassium hydroxide, has increased digestibility and often has increased voluntary intake and animal performance. Ammonium hydroxide (NH_4OH) has the potential of (1) reducing the chemical cost of treatment, and (2) increasing the crude protein content of the treated straw.

The objectives of these studies were to determine (1) the effect of length of time (days post-treatment) and water content of wheat straw on *in vitro* dry matter digestibility (IVDMD) and nitrogen retention of NH_4OH-treated straw, (2) the relative amounts of nitrogen retained as fiber-bound nitrogen versus free ammonia nitrogen (NH_3-N), and (3) the changes in digestibility of various fiber fractions of straw due to NH_4OH treatment.

Experimental Procedures

Experiment I.

Water was added to chopped wheat straw to result in final levels of about 10, 20, 30, 40 and 50 percent of dry matter. Ammonium hydroxide was then sprayed on the straw at a level that resulted in 3.3 percent ammonia (NH_3) being added on a dry matter basis. The treated straw was sealed in double plastic bags, and stored at room temperature for 10, 20, 30, 40 or 50 days before being frozen and ground with dry ice to pass through a 1 mm screen. Dry matter, total nitrogen and IVDMD were measured. Total nitrogen was analyzed by the Kjeldahl procedure and IVDMD by the Tilley and Terry procedure with urea (0.5 g/liter) added to the buffered rumen fluid and a 24 hr pepsin digestion phase. Also, dry matter, total nitrogen, fiber-bound nitrogen (ADF-N), and free ammonia-nitrogen (NH_3-N) were measured on the treated straw samples after they had been spread in a pan and aerated for 24 hr at room temperature. Free ammonia-nitrogen was analyzed by the magnesium oxide distillation step of the Kjeldahl procedure.

Changes in the digestibility of various fiber fractions as a result of NH_4OH-treatment were determined by analyzing the untreated straw and 3 treated straw samples for neutral-detergent fiber (NDF), acid-detergent fiber (ADF), acid-detergent lignin (ADL) and cellulose both *before* and *after* running IVDMDs on the samples. The 3 treated straw samples that were chosen were among those that had the highest IVDMDs after NH_4OH treatment.

The data were analyzed by regression analysis for a 5×5 factorial arrangement of treatments in a completely randomized design with two replications.

Experiment II.

Chopped wheat straw was treated the same as described for Experiment I in regard to ammonia and water level with the exception that a straw sample with no added water and ammonia was carried through each of the storage times. Storage times were 1, 5, 10, 20, 40 and 60 days. Treated samples were analyzed for IVDMD and total nitrogen after aeration as described for Experiment I. The data were analyzed by regression analysis for a 6×6 factorial arrangement of treatments in a completely randomized design with two replications.

Results and Discussion

Digestibility and total nitrogen content of straw

Both IVDMD (digestibility) and total nitrogen content of wheat straw were significantly increased by NH_4OH-treatment ($P<.01$). Although number of days post-treatment ($P<.05$) and moisture level ($P<.0001$) had significant linear effects on both digestibility and total nitrogen content,

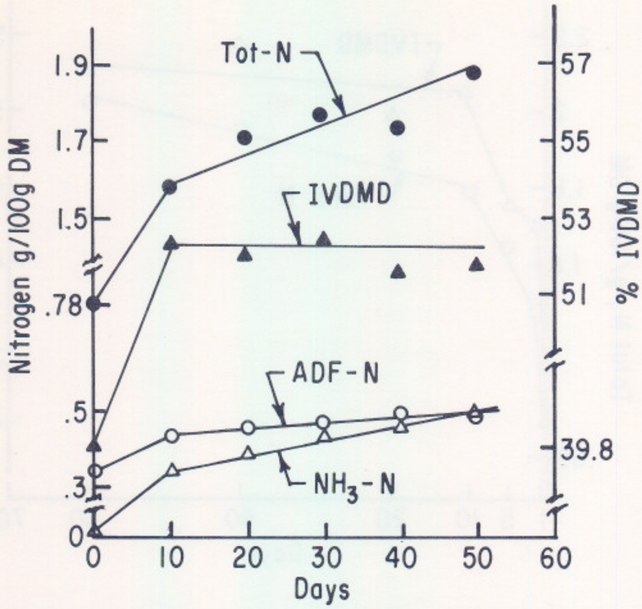

Figure 1. Nitrogen and IVDMD response to days post-treatment (Experiment 1)

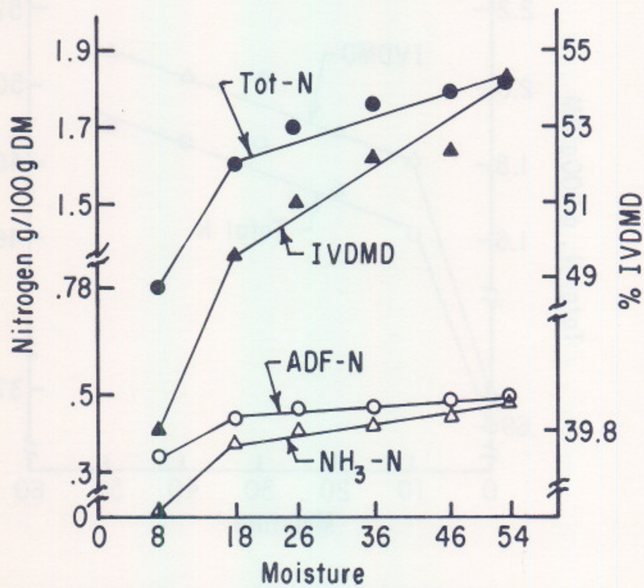

Figure 2. Nitrogen and IVDMD response to straw moisture level (Experiment 1)

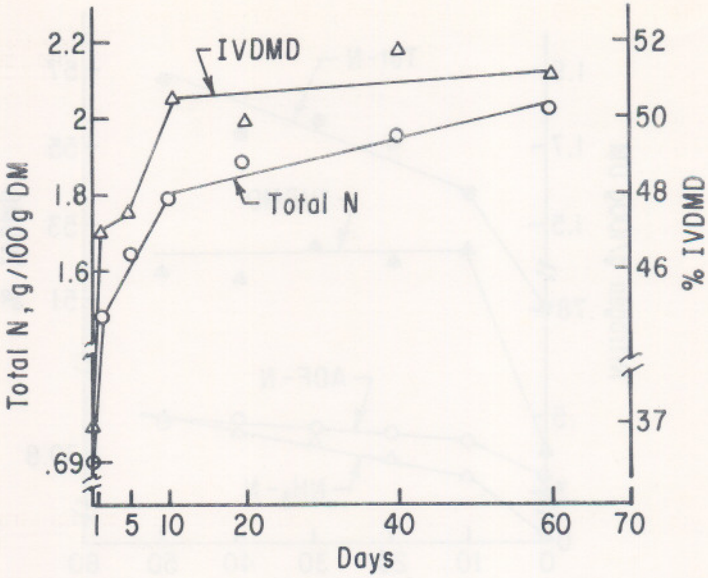

Figure 3. Nitrogen and IVDMD response to days post-treatment (Experiment 2)

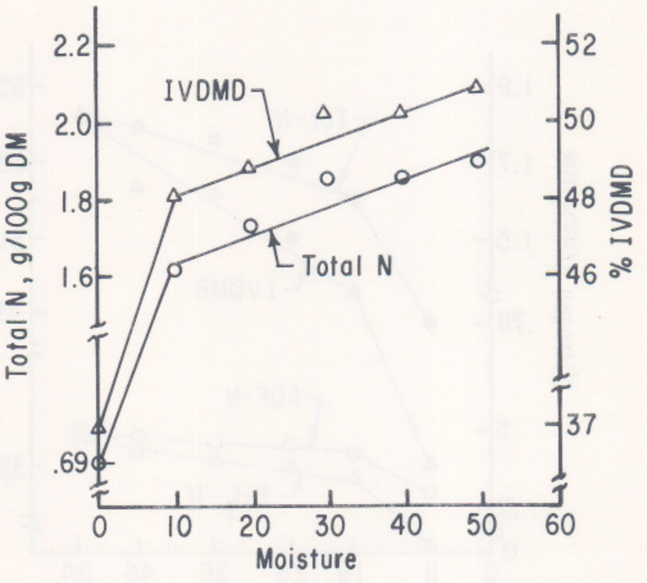

Figure 4. Nitrogen and IVDMD response to straw moisture level (Experiment 2)

Table 1. IVDMD and Total N content in wheat straw

	IVDMD (%)		Total N Content (g/100 g DM)	
Experiment No.:	I	II	I	II
Untreated straw	39.8	36.8	.78	.69
Treated straw[a]	52	49.64	1.73	1.79
% increase over untreated straw	30.6	34.9	122	159
Treated straw[b]	53.5[c]	52.4[d]	1.90[e]	2.13[f]
% increase over untreated straw	34.4	42.4	144	209

[a]Overall means of all day × moisture treatment combinations.
[b]Treated straw samples which showed maximum or near maximum increase in IVDMD or total nitrogen content.
[c]10 days × 54 percent moisture.
[d]10 days × 50 percent moisture.
[e]50 days × 54 percent moisture.
[f]60 days × 50 percent moisture.

Table 2. Total nitrogen, ADF-N and NH_3-N in treated wheat straw

	Untreated straw	Treated[a] straw	Treated[b] straw
Total N added			
g/100 g DM straw	----	2.72	----
Total N content			
g/100 g DM	.78	1.73	1.90
Total N retention,			
% of added	----	34.9	41.2
ADF−N			
g/100 g DM	.34	.46	.49
% of total N added	----	4.4	5.5
% of total N retained	----	12.6	13.4
NH_3-N			
g/100 g DM	.008	.42	.56
% of total N added	----	15.1	20.3
% of total N retained	----	43.4	49.3

[a]Overall means of all day × moisture treatment combinations.
[b]Treated straw sample (50 days × 54 percent moisture) which showed maximum or near maximum increase in total nitrogen content.

further improvements in digestibility after 10 days were small (Figures 1 and 3), and a large percentage of the improvement in digestibility had occurred by 5 days post-treatment (Figure 3). Total nitrogen content of the treated straw, however, continued to increase as days post-treatment increased (Figures 1 and 3). Both digestibility and total nitrogen content of treated straw continued to increase as moisture content increased (Figures 2 and 4). The overall improvements (e.g., mean of all day × moisture treatment combination) in IVDMD and nitrogen content due to NH_4OH treatment were: 30.6 and 34.9 percent (IVDMD) and 122 and 159 percent (total nitrogen content) for

Table 3. Solubilization and changes in digestibility of wheat straw fiber fractions[a] due to NH_4OH treatment

	Untreated[b] Straw	Treated straw[b]		Change due to NH_4OH		Change due to IVDMD		Total Change	
		Before IVDMD	After IVDMD	g/100 g DM	% of untreated straw	g/100 g DM	% of before IVDMD	g/100 g DM	% of untreated straw
NDF, g/100 g DM	73.3	67.0	60.2	− 6.3	− 8.6	− 6.8	−10.1	−13.1	− 17.8
NDS, g/100 g DM	26.7	33.0	39.7	+ 6.3	+23.6	+ 6.7	+20.3	+13.0	+ 48.7
ADF, g/100 g DM	49.1	53.2	52.6	+ 4.1	+ 8.3	− 0.5	− 1.0	+ 3.6	+ 7.3
ADL, g/100 g DM	7.7	8.5	16.6	+ 0.8	+10.4	+ 8.1	+95.3	+ 8.9	+115.6
Hemicellulose, g/100 g DM	24.1	13.8	7.6	−10.3	−42.7	− 6.2	−44.9	−16.5	− 68.4
Cellulose, g/100 g DM	39.5	42.3	31.3	+ 2.8	+ 7.0	−11.0	−26.0	− 8.2	− 20.7

[a]Neutral-detergent fiber (NDF), Neutral-detergent solubles (NDS), Acid-detergent fiber (ADF), Acid-detergent lignin (ADL).
[b]IVDMD of untreated and treated straw samples were 39.8 and 55.1 ± .37 percent, respectively.

Experiments I and II, respectively (Table 1). Maximum or near maximum improvements in IVDMD and total nitrogen content due to NH_4OH treatment were: 34.4 and 42.4 percent (IVDMD) and 144 and 209 percent (total nitrogen content) for Experiments I and II, respectively (Table 1).

Total nitrogen retention, ADF-N and NH_3-N

The overall mean quantity of nitrogen that was retained in the NH_4OH-treated straw samples was 0.95 g per 100 g dry matter (e.g., 1.73 minus 0.78 g) or 34.9 percent of the added nitrogen (Table 2). Fiber-bound nitrogen (ADF−N) and free ammonia nitrogen (NH_3-N) accounted for 12.6 and 43.4 percent of the retained nitrogen, respectively, when average across all day × moisture treatment combinations.

Concentrations and digestibility of fiber fractions

Total cell wall fiber (NDF) and the hemicellulose fraction were decreased 8.6 and 42.7 percent, respectively, by NH_4OH treatment alone (Table 3). During the IVDMD procedure 10.1, 44.9 and 26.0 percent of the NDF, hemicellulose and cellulose fiber fractions, respectively, which remained after chemical treatment disappeared or were digested. In total 17.8, 68.4 and 20.7 percent of the NDF, hemicellulose and cellulose fiber fractions, respectively, that were present in the untreated straw were lost due to the combination of (1) chemical effects on the fiber fractions and (2) digestibility during the IVDMD procedure. The total increase of 8.9 g for the ADL fraction would be the result of concentrating effects associated with the loss of the NDF, hemicellulose and cellulose fractions.

Stocker Bloat on Wheat Pasture

D. F. Frost, G. W. Horn, L. I. Croy and G. L. Burnett

Story in Brief

Ruminal motility and ruminal fluid foam stability, expansion and strength measurements were made on steers during the 1976-77 wheat pasture grazing season. Both the amplitude and frequency of ruminal contractions of steers on wheat pasture were generally increased, and did not indicate that reduced ruminal motility is a predisposing etiological factor in the bloating of wheat pasture stockers. Measurements of ruminal fluid foam stability, expansion and strength, taken as indices of the likelihood that stockers would bloat, did change significantly over the wheat pasture grazing period. However, multiple chemical components of wheat forage accounted for only 50.1 percent of the variation observed in the ruminal fluid stability measurements, and therefore would have low predictive value.

Introduction

Among the health problems of stocker cattle grazed on wheat pasture is one known as the stocker syndrome. Frothy bloat is a major cause of deaths in wheat pasture stockers that die of the stocker syndrome. Our studies relative to this problem during the 1976-77 wheat pasture grazing season have been conducted along the following lines of question: (1) Is wheat pasture bloat in stockers a secondary bloat to a reduced ruminal motility? (2) Does ruminal fluid foam stability, expansion and strength (as indices of bloat potential or the likelihood that stockers would bloat) change during the wheat pasture grazing season? (3) What changes in concentration do certain wheat forage chemical components, which are believed to be related to the incidence of bloat, undergo during the wheat pasture grazing season, and can they be used to predict bloat potential?

Experimental Procedure

Wheat pasture and steers

The studies were conducted on eight acres of wheat pasture at the O.S.U. Dairy Cattle Center. One-hundred and four pounds (104 lb) of triumph 64 seed were sown per acre on September 9, 1976. Prior to drilling, urea (143 lb/acre) was applied and 48 lb/acre of 18-46-0 fertilizer was included with the seed. There were no additional applications of nitrogen during the test period. The animal observations were taken from four ruminally cannulated Hereford X Angus steers (average initial wt of 535 ± 13 lb). The steers were placed on wheat pasture on November 13, 1976 and remained on pasture until March 24, 1977 (152 total days). The average daily gain of the steers while on wheat pasture was 2.1 ± .11 lb.

Ruminal motility

In order to establish baseline data, amplitude and frequency of ruminal contractions were measured for three consecutive weeks prior to putting the steers on wheat pasture, and for two consecutive weeks after the steers were taken off wheat pasture. The mean pre- and post-wheat pasture amplitudes and frequencies were not statistically different ($P>.05$). While off wheat pasture the steers were fed a ration that consisted of about 54 percent ground alfalfa hay, 32 percent corn, 7 percent cottonseed hulls and 5 percent soybean meal. Measurements of ruminal motility were taken from November 23, 1976 to March 15, 1977 during the wheat pasture grazing period. Ruminal motility of the steers was measured by placing implantable pressure transducers in the dorsal ruminal sac through small ruminal cannulas.

Ruminal fluid foam stability, expansion and strength

Measurements of foam stability, expansion and strength were made on ruminal fluid samples taken from the four rumen cannulated steers at approximately weekly intervals from December 21, 1976 to March 22, 1977. Rumen fluid samples were foamed in glass columns by passing compressed air through a fritted glass disc for 10 min at a constant pressure. Foam stabilities were estimated from the slopes (regression coefficients) of the resulting plots of foam height versus foaming time. Foam stability was defined as the rate of foam formation compared to the rate of foam breakdown, and increased as the magnitude of the regression coefficients increased. Foam expansion and strength were measured as the number of volumes of foam obtained from one volume of fluid (cm foam/ml fluid) at the end of the 10-min foaming period, and as the rate of fall (cm/sec) of a perforated brass weight through the produced foams, respectively.

Ruminal fluid viscosity

Ruminal fluid viscosity was measured as a possible alternative to measurements of ruminal fluid stability, expansion and strength. Studies have shown that ruminal fluid viscosity is increased in bloated animals possibly as a result of the rupturing of microbial cells and the subsequent spillage of cell contents into the rumen due to elevated intra-ruminal pressures. The measurements were obtained by using a No. C-155, size 100 viscometer . The data were expressed in units of centistrokes.

The experimental design used to analyze the ruminal motility and all measurements made on the rumen fluid samples was a randomized complete-block design with steers as blocks and time period as the treatment application. The date x steer mean square was used as the error mean square.

Wheat forage composition

Six random clippings were taken from the wheat pasture at weekly intervals from November 4, 1976 to March 24, 1977. Analysis of specific wheat forage components included: 1) dry matter, 2) neutral-detergent fiber (NDF) or total forage fiber, 3) total nitrogen (crude protein), 4) total soluble nitrogen, 5) soluble non-protein nitrogen and 6) soluble protein nitrogen. The neutral-detergent fiber analysis was by the procedure of Goering and Van Soest (U.S.D.A. Agr. Handbook No. 379, 1970). Analysis of the soluble nitrogen fractions was conducted using a mineral mixture from the "Ohio" *in vitro* fermentation media (Johnson, R. R., 1969, Techniques and Procedures in Animal Science Research).

The experimental design for analyzing the forage data was a completely randomized design with time periods (weeks) as the treatment. The sample x date mean square was used as the error mean square.

Results and Discussion

Ruminal motility

The mean amplitude and frequency of ruminal contractions during the pre- and post-wheat pasture, and the wheat pasture grazing period are shown in Table 1. The amplitude of ruminal contractions was significantly increased

Table 1. Ruminal motility of wheat pasture stockers (1976-77)

	Amplitude of contractions (mmHg)	Frequency of contractions (seconds)
Mean, pre- and post-wheat pasture periods:	17.1	23.8
Wheat pasture:		
11-23-76	17.3	31.7*
11-29-76	16.5	29.4
12- 7-76	18.0	32.7*
12-14-76	15.9	33.8*
12-28-76	15.9	30.6*
1- 4-77	23.5*	38.0*
1-18-77	33.5*	33.5*
2- 1-77	25.4*	28.7
2- 8-77	15.2	29.6
2-15-77	12.4	34.4*
2-22-77	26.6*	22.0
3- 1-77	11.0*	35.4*
3- 8-77	15.9	21.9
3-15-77	15.1	15.8*

*Significantly different from mean of pre- and post-wheat pasture periods ($P<.05$).

(P<.05) on four dates during the wheat pasture grazing period, whereas the mean amplitude on March 1, 1977 was significantly decreased (P<.05). Frequency of ruminal contractions were generally increased. In agreement with the ruminal motility measurements of the 1975-76 wheat pasture grazing season, these data do not indicate that reduced ruminal motility is a predisposing factor in the bloating of wheat pasture stockers.

Ruminal fluid foam stability, expansion, strength

The initial foam stability value (12-21-76) was assigned a value of 100 percent and the remaining values were expressed as a percentage of the initial value (Table 2). The most stable foam occurred on this date. Both foam stability and foam expansion showed similar patterns of remaining fairly constant until 2-15-77. The next week foam stability decreased to a level similar to that observed on 2-8-77 before decreasing even lower for the remainder of the wheat pasture grazing period. Foam expansion decreased on 2-22-77 and continued to decrease until 3-22-77.

No significant change over time was observed in the rumen fluid viscosity measurements, and they accounted for only 1.36 percent of the total variation in the foam stability measurements.

Wheat forage composition

All wheat forage components showed significant differences over time (P<.0001). The changes in forage dry matter, crude protein and neutral-detergent fiber (forage components which may reflect forage maturity and may be related to the incidence of bloat) are shown in Figure 1. The large, early increases in dry matter and neutral-detergent fiber, and the concomitant

Table 2. Rumen fluid foam stability, expansion, strength and viscosity measurements

	Stability				
Date	Linear regression coefficients	Percent of initial value	Expansion (cm foam/ml fluid)	Strength (cm/sec)	Viscosity (centistrokes)
12-21-76	$.715^{bc}$	100	1.22^{c}	1.27^{ab}	
12-28-76	$.68^{bc}$	95	1.155^{bc}	$.55^{a}$	
1- 4-77	$.63^{bc}$	88	1.18^{bc}	2.96^{c}	
1-18-77	$.60^{abc}$	84	1.14^{bc}	$.60^{ab}$	2.00^{a}
2- 1-77	$.577^{abc}$	81	1.19^{bc}	1.94^{abc}	2.01^{a}
2- 8-77	$.597^{abc}$	83	1.22^{c}	1.74^{abc}	1.68^{a}
2-15-77	$.892^{c}$	125	1.31^{c}	$.91^{ab}$	1.57^{a}
2-22-77	$.575^{abc}$	80	$.755^{abc}$	1.78^{abc}	1.44^{a}
3- 1-77	$.21^{ab}$	29	$.425^{ab}$	1.08^{ab}	1.63^{a}
3- 8-77	$.19^{ab}$	27	$.422^{ab}$	1.30^{ab}	2.19^{a}
3-15-77	$.06^{a}$	8	$.325^{a}$	2.04^{bc}	1.66^{a}
3-22-77	$.28^{ab}$	39	$.572^{abc}$	2.87^{c}	

[abc]Means in the same column that have common lettered superscripts are not statistically different (P>.05).

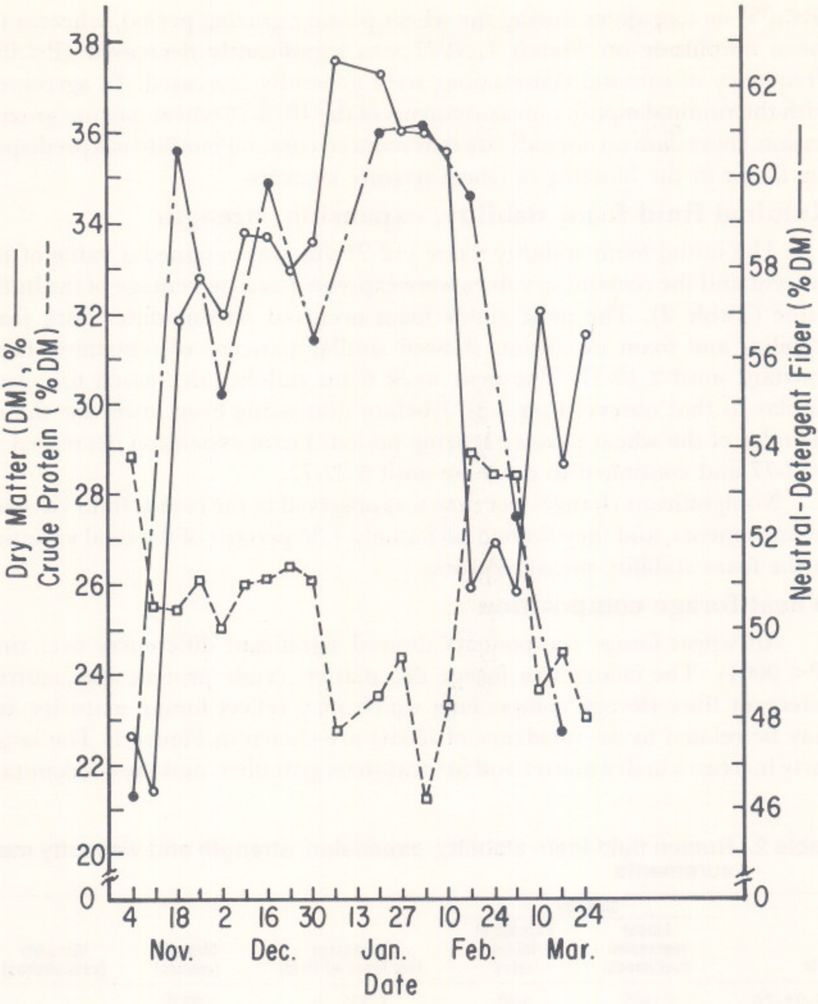

Figure 1. Dry matter, crude protein and neutral-detergent fiber content of wheat forage

decrease in forage crude protein content are probably reflective of the effect of the extremely dry and cold fall of 1976 on wheat forage growth.

Coefficients of determination (R^2values) for the regression of ruminal fluid foam stability, expansion or strength on single or multiple chemical components of wheat forage are shown in Table 3. The R^2 values represent what portion (percent) of the variation of a dependent variable can be accounted for by an independent or multiple independent variables. The inde-

Table 3. Coefficients of determination (R^2 values) for regression of ruminal fluid foam stability, expansion or strength on chemical components of wheat forage

Dependent variable	Number of independent variables	Dry matter	Crude protein	NDF[a]	Total soluble N	Soluble protein N	Soluble NPN[b]	R^2 value
Foam stability	1			X				.360
	2		X	X				.418
	3		X	X		X		.459
	4		X	X	X		X	.487
	5	X	X	X	X	X		.501
Foam expansion	1			X				.332
	2			X			X	.343
	3		X	X		X		.367
	4		X	X	X		X	.382
	5	X	X	X	X	X		.393
Foam strength	1					X		.232
	2	X	X					.485
	3				X	X	X	.488
	4	X	X	X		X		.492
	5	X	X	X	X		X	.493

[a]Neutral-detergent fiber (total forage fiber).
[b]Non-protein nitrogen.

pendent variables (forage chemical components) listed in Table 3 are believed to be related to the incidence of bloat based on chemical analyses of wheat forage samples taken from pastures within the state (1) where bloat was not observed or (2) where stockers were frequently seen bloated or had died of bloat. Forage crude protein and neutral-detergent fiber components accounted for 41.8 percent of the variation in ruminal fluid foam stability, and only 50.1 percent of the variation was accounted for by wheat forage dry matter, crude protein, NDF, total soluble nitrogen and soluble protein nitrogen concentrations.

Plant Chemical Composition and Digestibility of Rangeland Forage

R. Ball, D. G. Wagner, J. Powell and R. W. Hammond

Story in Brief

Forage samples were collected on a monthly basis from various points on a native rangeland watershed located near Stillwater. The forage samples were collected according to grazed (G) and caged (C). Both live and standing dead plants were collected. The samples were analyzed for fiber (ADF), lignin (ADL) and cellulose (CELL) for both grazed (live and dead) and caged (live and dead). The grazed dead acid detergent fiber (GDADF) and caged dead acid detergent fiber (CDADF) values were similar in August, being 51.0 percent (GDADF) *vs* 51.1 percent (CDADF). The grazed standing vegetation (GSTDV) showed an overall increase in ADF fiber composition from 45.7 percent in October to 52.5 percent in January.

In vivo digestion data showed a decrease in digestion when there was an increase in fiber. The ADF rose from 51.5 percent in May to 54.3 percent in July. *In vivo* digestibility at these same times decreased from 23.9 percent in May to 21.8 percent in July.

Introduction

Beef cattle are major consumers of forages, and rangelands will likely be relied upon to supply more of the forages needed. Due to higher grain prices and greater demand of grain for human consumption and export, more livestock will need to be maintained and grown with greater forage utilization. A broader understanding of the chemical make up of forages throughout the growing and grazing seasons is beneficiary to proper nutritional management and improved range forage utilization. The purpose of this study was to determine the chemical composition (acid detergent fiber, lignin, and cellulose) of rangeland forage, grazed and ungrazed, throughout the year and to relate changes in plant chemical composition to digestibility of the forage.

Materials and Methods

The study area consists of a 70 hectare watershed located at the Northwest end of Lake Carl Blackwell in Noble County, Oklahoma. Both live and dead standing vegetation were collected, except for winter months when a clear distinction could not be obtained between dead and live plants. During these months the forage was described as standing vegetation. Both caged and grazed samples were collected, from twenty-nine various locations on the watershed. Three enclosures (0.5 acres each) at various points on the watershed were constructed to serve as controls, unaccessible to the cattle.

Three Holstein steers (408 kg) were fitted with rumen cannulaes for the purpose of running nylon bag *in vivo* digestion trials. The nylon bag *in vivo* digestion trials were run on a monthly basis as were the forage collections. Preweighed samples of forage are placed in nylon bags and placed in the rumen for an incubation period of 48 hr. After 48 hr the bags are removed, dried at 55 C for 48 hr and weighed back. The dry matter digestibility is calculated as the percent disappearance during incubation.

Acid detergent fiber, lignin, and cellulose were determined on the forage samples collected. The forage was analyzed for acid detergent fiber and then for lignin by the permanganate method. The cellulose was determined by difference, ashing the remaining sample after lignin determination.

Results and Discussion

Chemical composition data for the period from August, 1976 to July, 1977 are shown in Tables 1, 2 and 3. The fiber contents of grazed (G) and caged (C) dead forage samples were almost identical (51.0 *vs* 51.1 percent) during August indicating grazing selectively by cattle to avoid the dead plants. The ADF for the standing vegetation showed an increase from October (45.7 percent) to January (52.5 percent). A decrease in fiber content was then noted from January (52.5 percent) to March (51.3 percent) and April (48.0 percent), reflecting the beginning of some growth in April. The same increase was noted for lignin and cellulose from October to January. The increased fiber content is

Table 1. Chemical composition of live and dead forage-acid detergent fiber (ADF) content

Month	Grazed dead ADF %	Grazed live ADF %	Caged dead ADF %	Caged live ADF %	Grazed standing vegetation ADF %	Caged standing vegetation ADF %
August	51.0	39.0	51.1	37.6		
September	49.3	36.3				
October					45.7	
November					48.3	
December					51.5	
January					52.5	
March					51.3	
April					48.0	47.1
May	51.5	36.6				
June	52.6	40.0				
July	54.3	43.0	54.5			

Table 2. Chemical composition of live and dead forage-acid detergent lignin (ADF) content

Month	Grazed dead ADL %	Grazed live ADL %	Caged dead ADL %	Caged live ADL %	Grazed standing ADL %	Caged standing ADL %
August	13.0	10.2	18.4	10.7		
September	14.1	10.3				
October					11.3	
November					11.7	
December					12.6	
January					13.3	
March					11.0	
April					9.3	9.2
May	10.8	7.0				
June	10.6	8.4				
July	14.2	9.6	15.6			

Table 3. Chemical composition of live and dead forage-cellulose content

Month	Grazed dead cellulose %	Grazed live cellulose %	Caged dead cellulose %	Caged live cellulose %	Grazed standing vegetation cellulose %	Caged standing vegetation cellulose %
August	37.9	29.9	37.7	29.5		
September	37.0	27.9				
October					34.3	
November					33.5	
December					35.1	
January					36.6	
March					35.8	
April					34.5	35.0
May	35.8	28.8				
June	37.0	29.7				
July	36.8	31.5	36.4			

Table 4. *In vivo* dry matter digestibility (48 hr disappearance)

Months	Grazed dead %	Grazed live %	Caged dead %	Caged live %	Grazed standing vegetation %
August	22.0	50.4	19.9	47.6	
September	18.1	44.8			
October					30.0
November					21.9
December					23.9
January					23.0
March					18.8
April					28.6
May	23.9	49.1			
June	17.4	42.8			
July	21.8	48.1	24.3	43.5	

due to the plants going into winter dormancy and the movement or storing of more nutrient reserves into the root system. Having a lower soluble carbohydrate content, the forages would have more fiber.

Digestibility data (Table 4) show a substantial reduction in digestibility for dead *vs* live plant material during all warm months. This was true for both caged (ungrazed) and grazed (access to grazing permitted) samples. As expected, digestibility of the standing vegetation was much lower during the period from November to March. In general, digestibility differences were often on the order of two-fold; between the live *vs* dead forages, and between growing *vs* non-growing months of the year. As fiber increases over any particular time, digestibility decreases.

Effect of Forage Density on Grazing Behavior, Forage Intake and Animal Performance

S. W. Coleman and F. P. Horn

Story in Brief

Sorghum sudan hybrid (Sx-17) was planted at three seeding rates (A, 16.8; B, 33.6 and C, 50.4 kg/ha) to determine the effect of different forage densities on grazing behavior, forage intake and animal performance of beef heifers. Two 1.2 ha pastures were used for each seeding rate. All pastures received 57 kg/ha of actual nitrogen at planting time. Four animals grazed each pasture from July 1 to September 29, 1977. An intake trial was conducted from July 26 to August 8, 1977, using chromic oxide as an external marker. During this time, one animal in each pasture was fitted with an 8-day recorder to continuously monitor grazing behavior.

There was a high correlation between grazing time measured by visual observation and that estimated when the vibration recorder was used (r=.92). Further, the activity of one animal in each pasture represented the activity of about 75 percent of the other animals in the pasture within a given five minute interval. This indicates the animals behave primarily as a group rather than as individuals.

In cooperation with USDA, Science and Education Administration, Southern Region.

Forage density for seeding rates A, B and C respectively was 715, 815, and 950 kg/ha ($P<.10$) on August 1 and 1220, 1155 and 1400 kg/ha on August 8. The fast growth rate of the forage reduced differences in density as the trial period progressed. Forage samples contained 56 percent neutral detergent fiber and 73 percent *in vitro* dry matter digestibility. Leaves accounted for 52.5 percent; stems 13 percent; extraneous material (dry material, weeds, etc.) 34.6 percent of the sample dry weight. There were no differences in either chemical or physical composition due to seeding rate. The amount of time spent grazing was 8.7, 12.0 and 9.4 ($P<.1$) hr/day and time spent grazing within each grazing period was .6, 1.02 and .8 hr for seeding rates A, B and C respectively. Dry matter intake was 8.6, 8.6 and 7.6 kg/day and gains were .52, .34 and .45 kg/animal/day and 208, 150, 217 kg/ha for the 90 day grazing period for seeding rates A, B and C, respectively.

The accuracy and utility of the vibration recorder demonstrate that this device can be used to monitor grazing behavior and will greatly reduce the labor requirements for such experiments.

Introduction

In contrast to feedlot type rations, high or total forage rations are not very well characterized for their nutrient value or production potential. Much forage is harvested by the grazing animal, and one of the most perplexing problems encountered by animal scientists is measuring voluntary forage intake. Methods used to estimate voluntary intake at the present time give only rough estimates. Many factors influence voluntary intake such as behavior of grazing, time spent grazing and search rate of the animal. These problems and factors, and the interactions of the soil-plant-animal system will need to be defined if we are to predict production in terms of output per animal, output per unit of land area or per unit of input (dollars, feed, etc.) for any given set of conditions. The objectives of this study were to determine the effect of forage density on grazing behavior, forage intake and animal performance.

Materials and Methods

Six 1.2 ha pastures of sorghum sudan (Sx-17) were seeded in duplicate at three rates: A, 16.8; B, 33.6 and C, 50.4 kg/hectare. Pastures were fertilized at the time of planting with 56 kg/ha of actual nitrogen. Soil type was Dale siltloam with 0-1 percent slope, moderately permeable on a wide terrace in a "second river bottom". Four Hereford x Angus heifers grazed each pasture from July 1 to September 29, 1977. Initial weights were approximately 275 kg each. Beginning July 26, and continuing for 14 days, three animals in each pasture were dosed with shredded paper imbedded with chromic oxide and pressed into pellets. Three such pellets weighing a total of about 30 grams were given to each animal each day at 8 am. During the last seven days, fecal samples were collected at the time of chromium administration. On the last day, a partial diurnal curve was established from 6 am to 8 pm to determine if there were interactions between time of sampling and seeding rate. Hand plucked samples of forage were taken three times during the collection period. These samples were analyzed for *in vitro* dry matter digestibility (Tilley and Terry, 1963). Also, at the beginning and at the end of the collection period, yield samples were hand clipped at 2.5 cm from a ½ M^2 circle at two locations within each pasture and dried at 65 C. This value is shown as forage density. The yield samples were separated into (1) leaf, (2) stem and (3) weeds or other extraneous material. One animal in each pasture was fitted with an 8-day recorder to allow continuous monitoring of grazing behavior (Stobbs, 1970).

Of primary importance in this trial was to determine the feasibility of using the vibration recorder to monitor grazing time and thereby eliminate the need for constant observation of the animals. During one day (daylight hours only) the animals in each pasture were observed and their activity was recorded at five minute intervals. This was correlated with results from the recorder to determine its accuracy.

Results and Discussion

The correlation coefficient between "*actual*" and "*recorded*" for starting time of a grazing period was .999 and for the end of a grazing period was .997 (Table 1). The regression coefficient (slope) was .99 in both cases. Grazing time in hours, however, was not as closely related. It resulted in a correlation coefficient of .92 and regression coefficient of .89. One possible explanation for this is probably the lack of variation in the length of the grazing period. The average period of grazing was about .8 hr.

Another point of interest is how closely animals behave as a group. During the one day observation period, activity of all animals was recorded as well as that of the animals wearing recorders. Analysis of these data indicate that in any five minute period, 73 percent of the animals were doing the same thing (Table 2). Further, 75 percent of the animals were grazing if any one animal was grazing during any given five minute interval. Therefore it was concluded that the vibration recorder was satisfactory as a method of recording grazing time and that one animal per group may represent the majority of the group. This has been previously shown by other researchers (Stobbs, 1970; Castle *et al.*, 1975).

Cr_2O_3 ratio was not influenced by the interaction between seeding rate and sample time. A graphic illustration is presented in Figure 1. Excretion was significantly ($P<.05$) affected by time with a peak appearing 6-9 hr after dosing.

Forage density at the beginning of the intake trial significantly ($P<.1$) increased with increasing seeding rate (Table 3). However, by the end of the

Table 1. Accuracy of vibration recorder

Variable	Intercept	b[a]	r[b]
Start grazing, hr	2.92	.987	.999
Stop grazing, hr	7.49	.991	.997
Grazing time, hr	.11	.896	.925

[a]Regression coefficient.
[b]Correlation coefficient.

Table 2. Group behavior of heifers

Item	Seeding Rate, kg/ha 16.8	33.6	50.4
Animals engaged in similar activity, %[a]	77.7	68.5	72.6
Animals grazing, %[b]	86.0	66.6	71.8

[a]Within a given five minute interval, the percentage of animals engaged in similar activity.
[b]Within a given five minute interval, the percentage of animals grazing when the animal with the recorder was grazing.

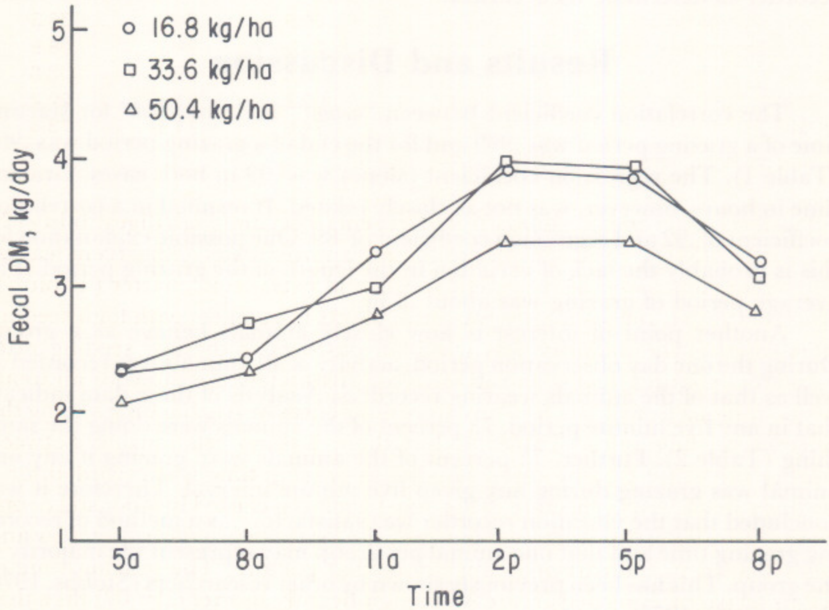

Figure 1. Diurnal effects on fecal dry matter excretion as determined by Cr_2O_3 ratio

trial, growth rate of the forage had been so rapid that average differences were obscured.

Composition of the hand plucked forage is shown in Table 4. Quality was high as expected since leaves were selected. This is illustrated by relatively low

Table 3. Pasture characteristics

Item	Seeding rate, kg/ha 16.8	33.6	50.4
Forage density, start, kg/ha	715[a]	815[a]	950[b]
Forage density, end, kg/ha	1220	1155	1400
Forage density, average, kg/ha	967	985	1175
Leaf, %	50.1	50.9	56.5
Stem, %	11.9	13.9	13.2
Extraneous, %	37.9	35.2	30.3
Leaf:stem, start[d]	5.8	6.2	6.8
Leaf:stem, end[d]	4.2	2.7	3.0
Leaf:stem, average	5.0	4.5	4.9

[a, b]Means in same row not followed by common superscript are significantly different.

[c]Percentage of stem was significantly ($P<.05$) lower at the beginning of the trial than at the end.

[d]Leaf:stem ratio was significantly ($P<.05$) lower at the end of the trial than at the beginning.

Table 4. Forage composition (hand plucked samples)

Item	Seeding rate, kg/ha 16.8	33.6	50.4
Neutral detergent fiber, %	55.9	54.8	56.3
Acid detergent fiber, %	28.5	28.3	28.8
Lignin, %	3.5	3.5	3.6
Cellulose, %	22.3	21.8	22.2
IVDMD, %[a]	74.6	74.5	73.4

[a]*In vitro* dry matter disappearance (Tilley and Terry, 1963).

cell wall content (56 percent neutral detergent fiber) and high digestibility (74 percent IVDMD). Yield samples contained approximately 52 percent leaves, 13 percent stems, and 34.5 percent weeds and extraneous matter (Table 3). Much of the extraneous matter was dead plants in pastures with high seeding rates whereas the majority was weeds in pastures of the low seeding rate. Using these figures, leaf:stem ratio was approximately the same for all treatments, ranging from 4.5 to 5. There were differences in grazing time among the different seeding rates (Table 5), but there was no relationship between seeding rates and grazing time. Maximum grazing time was recorded for a seeding rate of 33.6 kg/hectare. This may have been caused by poor soil in one of the replicates of this treatment in which the forage density was quite low and was reflected in the carrying capacity of that pasture. The grazing time of heifers on pastures seeded at rate A was significantly shorter ($P=.07$) than that of heifers grazing pastures seeded at rate B. Grazing time on seeding rate C was intermediate between the other two. Hours per grazing period followed the same trend as that of grazing time per day. There were approximately the same number of grazing periods per day for all of the treatments. This indicated a very "ordered" behavior among animals. This phenomenon can also be noted in day to day periods of grazing which occurred at approximately the same time and by all animals.

Table 5. Animal behavior, consumption and performance

Item	Seeding rate, kg/ha 16.8	33.6	50.4
Grazing time, hrs			
Daily	8.7[b]	11.9[c]	9.4[b, c]
Per grazing period	.60[b]	1.02[c]	.78[b]
Dry matter intake, kg/day	8.6	8.6	7.6
Daily gain, kg	.52	.34	.45
Animal days	159	153	169
Gain, kg/ha[a]	208[b]	150[c]	218[b]

[a] 91 days grazing.

[b, c] Means in same row not followed by same superscript are significantly different ($P<.05$).

Animal response data included dry matter intake, gain per animal and gain per hectare (Table 5). Dry matter intake and gain per animal was not significantly affected by treatment; however, there were numerical differences especially in gains per animals. This was inversely proportional to grazing hours spent each day. Dry matter intake was about 7.5 to 8.5 kg/day which is reasonable for animals this size, but gains were low for that level of TDN intake. This may suggest that intake was either slightly overestimated or that TDN intake over the entire period was not as high as during the trial. Gains ranged from .34 to .52 kg/day. Gain per hectare for the 90 day grazing season followed similar to animal daily gains. Pastures seeded at rate B produced lowest gains and were significantly different from the other two.

These preliminary trials indicate that to monitor effects of forage density on behavior and intake of grazing animals, a forage likely to respond less in terms of growth for a short period of time would be better suited than sorghum sudan hybrids. Permanent pastures would not only be more suitable experimentally, but would provide information of more use to cattlemen. Several stocking rates or grazing pressures might be used to achieve the various plant or forage densities. Further, as plants become shorter, animals may have a more difficult time prehending the forage and intake may be limited by bite size (Stobbs, 1975). This parameter should also be incorporated into future studies of this type.

Literature Cited

Castle, M. E., Elizabeth Macdaid and J. N. Watson. 1975. The automatic recording of the grazing behavior of dairy cows. J. Br. Grassld. Soc. 30:161.

Stobbs, T. H. 1970. Automatic measurement of grazing time by dairy cows on tropical grass and legume pastures. Trop. Grassld. 4:237.

Stobbs, T. H. 1975. Factors limiting the nutritional value of grazed tropical pastures for beef and milk production. Trop. Grassld. 9:141.

Tilley, J. M. A. and R. A. Terry. 1963. A two-stage technique for the *in vitro* digestion of forage crops. J. Brit. Grassld. Soc. 18:104.

Rumensin and Digestibility of Feedlot Rations

J. H. Thornton, F. N. Owens and R. W. Fent

Story in Brief

Rumensin was added to a 95 percent concentrate, whole shelled corn ration containing 9 or 12 percent protein. Rumensin addition reduced intake by steers 9 percent but increased digestibility. Intake of digestible dry matter was not changed. Rumensin increased digestibility of the 12 percent protein ration by about 1 percent and of the 9 percent protein ration by over 4 percent. Benefits of Rumensin feeding on digestibility appear greater with low protein rations.

Introduction

Previous studies have shown that Rumensin addition to whole corn feedlot rations may be more useful with low than high protein rations (Gill *et al.*, 1977). Reduction of methane loss by Rumensin feeding (Thornton *et al.*, 1977) cannot explain this response. This experiment was conducted to examine if digestibility is increased by Rumensin.

Experimental Procedure

Whole shelled corn rations similar to those used in the earlier feedlot trial (Gill *et al.*, 1977) were fed (Table 1) free choice to 12 Angus steer calves. Rumensin was added at a level of 33 ppm in the pelleted soybean meal, mineral-vitamin supplement. Steers averaged 630 lb at the start of the trial and were rotated among the 4 rations. Feces and urine were collected the last 5 days of each 14 day period during which a ration was fed. Digestibility of dry matter, starch and protein were measured and retention of nitrogen was calculated.

Results and Discussion

Rumensin addition across the two protein levels depressed intake by 9 percent (Table 2). Such an intake reduction is commonly observed with Rumensin feeding. Energy digestibility was increased by Rumensin. This

Table 1. Ration composition

Protein content, %	9.4	12.2
	%	
Whole shelled corn	90.8	84.6
Cottonseed hulls	4.8	4.8
Pelleted supplement:		
Soybean meal	0	8.6
Cracked corn	1.7	0
Alfalfa meal	1.0	1.0
Limestone	1.0	1.0
KCl	0.3	0
Salt	.3	.3

Table 2. Rumensin effects

	0	33 ppm
Intake		
Dry matter, lb.	12.5	11.4
Energy[a]	60.2	59.6
Digestibility, %		
Dry matter	78.2	81.1
Protein	68.7	71.6
Starch	94.1	95.8
Nitrogen retained		
g/day	32.4	32.8

[a]Digestible dry matter, g/kg$^{3/4}$

compensated for the reduced intake, so that intake of digestible energy was unchanged. Protein and starch digestibility were also increased slightly by Rumensin, but nitrogen retention was not changed.

Protein level of the ration had little effect on feed intake (Table 3). Digestibility of dry matter and protein were higher with the higher protein ration. Protein digestibility was elevated because soybean meal protein is more digestible than corn grain protein. Starch digestion and nitrogen retention also were increased slightly by added protein.

Since Rumensin and protein effects on digestibility were similar, the effects of Rumensin at each protein level were examined (Table 4). Rumensin

Table 3. Protein effects

	9.4%	12.2%
Intake		
Dry matter, lb.	12.1	11.9
Energy[a]	58.4	61.4
Digestibility, %		
Dry matter	78.4	80.9
Protein	66.8	73.5
Starch	94.2	95.6
Nitrogen retained,		
g/day	30.3	34.9

[a]Digestible dry matter, g/kg$^{3/4}$

Table 4. Protein-Rumensin interactions

Protein, %	9.4		12.2	
Rumensin, ppm	0	33	0	33
Digestibility, %				
Dry matter	76.2	80.6	80.1	81.6
Starch	92.5	96.0	95.7	95.5
Starch, % of				
fecal weight	19.4	12.1	12.9	12.3

had its greatest impact on digestibility of dry matter and starch at the lower protein level. This suggests that Rumensin is more useful with low protein rations. One way that Rumensin may improve digestibility is by lengthening of the time period feed spends in the rumen for digestion. This change would prove more useful with forages and coarse grains than highly processed grains. Improved digestibility of the ration may explain some of the observed feedlot benefits of Rumensin feeding.

Literature Cited

Gill, D. R., F. N. Owens, J. J. Martin, D. E. Williams and J. H. Thornton. 1977. Protein levels and Rumensin for feedlot cattle. Okla. Agri. Exp. Sta. MP-101:42.

Thornton, J. H. and F. N. Owens. 1977. Rumensin effects on energy losses at three fiber levels. Okla. Agri. Exp. Sta. MP-101:53.

Buffers and High Moisture Corn Digestion

J. H. Thornton, F. N. Owens, R. W. Fent and K. Poling

Story in Brief

High moisture corn (HMC) of two moisture levels, 23 and 30 percent, with added dolomitic limestone, bentonite, Liquid Trace Mineral or sodium bicarbonate were fed to 20 steers. Digestibility of the wetter HMC was higher, largely due to greater starch availability. Intakes and feed efficiencies were slightly greater with wetter HMC. One additive, dolomitic limestone, elevated fecal pH, but with a calcium level at 0.45 of the ration, no added materials improved digestibility of starch, dry matter or protein. A low calcium level, 0.36 percent, may reduçe dry matter and starch digestibility. Elevating fecal pH from 6.2 to 6.9 with added buffers did not increase digestibility of starch from high moisture corn.

Introduction

The recent symposium on High Moisture Corn Research (High Moisture Corn Conference, 1976) indicated that nutritive value of high moisture corn (HMC) may vary with moisture content. A higher moisture level (26-30 percent) is generally used more efficiently by feedlot steers than drier HMC. Greater starch digestibility in the rumen and intestines may be responsible.

Work from Purdue University (Wheeler and Noller, 1976) has suggested that digestibility of starch in the intestine of cattle is inhibited by acid, and that added buffers aid in digestion of starch. Acidity of feces generally paralleled the amount of starch present in feces.

The objective of this study was to examine the influence of 5 diet additives on starch and dry matter digestibility of HMC of two moisture contents when fed to steers. Efficiency of feed use was also monitored.

Materials and Methods

Ten Angus steers averaging 870 lbs were fed each of 2 HMC. The wetter HMC contained 30.3 percent moisture and the drier HMC analyzed 23.4 percent moisture. Further composition is shown in Table 1. Mixtures of the HMC-cottonseed hull-bufferred supplement (Tables 2 and 3) were fed *ad libitum* for 10 day periods with chromic oxide, an indigestible marker, included the final 7 days. Steers were rotated among buffer treatments within a corn moisture level. On day 10 of each period, steers were weighed and fecal samples were obtained from each of the 20 steers. Determinations on feces and on feed samples included pH, starch, dry matter, chromium, protein and ash. By relating level of the indigestible added chromium in feed to its level in feces, digestibilities of starch, dry matter, protein, ash and organic matter were calculated.

Table 1. Corn analyses

Corn	Wetter	Drier
Moisture	30.3	23.4
Protein, % of dry matter	8.96	8.87
Soluble N, % of total N	50.2	17.0

Table 2. Ration composition, percent of dry matter

Item	%
High moisture corn	80.6
Cottonseed hulls	10.0
Supplement	9.4

Results and Discussion

HMC moisture level

Fecal pH was markedly lower with the drier HMC (Table 4). Also starch content was almost tripled in feces from steers fed the drier HMC as compared with steers fed the wetter HMC. In an earlier trial in this publication (Thornton *et al.*, Rumensin and Digestibility of Feedlot Rations) these same steers produced feces from a whole corn-rumensin-supplemental ration containing 12.2 percent starch. Heifers in a local feedlot fed a whole corn ration averaged 19.4 percent starch in feces. Ash content also indicates lower digestibility of the drier HMC. Digestibility of dry matter and starch (Table 5) proved lower with the drier corn, but protein digestibility was unchanged. Lower starch digestion and lower fecal pH would suggest that some relationship exists, and elevating fecal pH may aid digestion.

Performance over the trial is shown in Table 6. Intakes and performance certainly were below that observed in feedlots. This may be due to the close confinement conditions or to the small mature size of the Angus steers used in this trial. Intakes, performance and feed efficiency tended to favor the wetter HMC. Calculated metabolizable energy was over 5 percent greater and digestibility about 3 percent greater for the wetter HMC than the drier HMC. Slightly greater energy loss during drying also would be expected with the wetter HMC. Results suggest that HMC containing 30 percent moisture is 3 to 5 percent more useful for feedlot steers than HMC at 23 percent moisture. Fermentation and vaporization losses may be slightly greater, but oxidation loss should be less with 30 percent moisture corn.

Visually, the drier HMC is bright, floury and dusty. The wetter HMC is brown-orange to gray and more sour. Its high soluble nitrogen level has been criticized in the past, but performance and digestibility results of this trial indicate more value from the wetter HMC. Whether water addition to drier

Table 3. Supplement compositions, as percent of total ration

Ration	Lime	Dolo lime	Bent.	LTM	Sodium bicarb	Low Lime
Soybean meal	4.3	4.2	4.2	4.2	4.2	4.3
Alfalfa meal	.83	.82	.81	1.06	.81	.83
KCl	.12	.12	.12	.12	.12	.12
TM Salt	.24	.24	.24	.24	.24	.24
Vit A & D	+	+	+	+	+	+
Rumensin	+	+	+	+	+	+
Limestone	1.23	0	1.20	1.20	1.20	.90
Dolomite	----	1.90	----	----	----	----
Bentonite	----	----	1.99	----	----	----
LTM	----	----	----	.075	----	----
Bicarbonate	----	----	----	----	1.50	----
Ground corn	2.62	2.03	.85	2.70	1.28	2.93
Ration analyses						
N, %	1.61	1.57	1.57	1.60	1.59	1.59
Ca, %	.47	.44	.46	.49	.46	.36

Table 4. Intakes and composition of feces from steers fed HMC

Corn moisture, %	30.3	23.4
pH	6.75[a]	6.31[b]
Starch[c]	6.7[a]	17.7[b]
Ash[c]	10.6[a]	8.8[b]

[ab]Means with different superscripts differ statistically ($P<.01$).
[c]As percentage of dry matter.

Table 5. Digestibility of ration nutrients from HMC rations

Corn moisture, %	30.3	23.4
Dry matter, %	78.2[a]	76.1[b]
Starch, %	97.3[c]	92.2[d]
Protein, %	67.4	66.1

[ab]Means with different superscripts differ statistically ($P<.10$).
[cd]Means with different superscripts differ statistically ($P<.01$).

Table 6. Performance[a] of steers fed HMC rations

Corn moisture, %	30.3	23.4
Intake, lbs.		
dry matter	14.6	14.3
Daily gain, lbs.	2.41	2.12
Feed/gain	6.41	7.02

[a]Averaged over 51 day trial.

corn or reconstitution can restore starch availability to a level equal to that of corn grain harvested at a higher moisture level is not certain.

Buffer additions

The level of calcium in all rations (except the low lime ration) was 0.44 percent or above. This is similar to feedlot rations used in the Great Plains. The "low lime" ration contained 0.36 percent calcium, considerably above the estimated requirement of 0.28 percent stated by the NRC. Dolomitic limestone level (1.90 percent of diet) provided an equal level of calcium as the limestone ration (1.23 percent supplemental limestone). Bentonite, liquid trace mineral and sodium bicarbonate were added to the limestone supplemented ration. Additives were included at recommended levels; results may not apply to other additive levels, other basal calcium levels or other feedstuffs.

Feed intakes were not statistically altered by treatments (Table 7). Fecal pH was consistently elevated by dolomitic limestone addition. This has been noted with dairy cattle previously (Wheeler and Noller, 1976). The lowest fecal pH was with the low limestone ration. Fecal starch concentration was not influenced by treatment. The treatment that produced feces with the highest pH had the third highest fecal starch content. This fact questions whether starch digestion can be altered by modifying fecal pH through feed additives.

Fecal ash content was higher with dolomitic limestone and bentonite additions. Of the minerals added beyond limestone, virtually none (6 and 4 percent) of the added dolomitic limestone and bentonite was absorbed. The dolomitic limestone buffered fecal pH, but the bentonite did not. Sodium bicarbonate may have buffered rumen pH, it would not appear in feces due to release of CO_2 and absorption of the sodium.

Digestibility of dry matter and starch were slightly higher with limestone alone than with further additives. The low limestone seemed especially low, suggesting that digestibility may be enhanced by feeding limestone at levels to exceed the NRC requirement. Protein digestibility also was low for the low limestone ration. Bentonite previously has been shown to complex with ammonia and depress apparent protein digestion. None of the tested additives improved starch or protein availability when added to a 0.45 percent calcium feedlot ration. Dolomitic limestone increased pH of feces but did not improve starch digestion. At lower diet calcium levels or fecal pH, effects of pH on starch digestion may be found.

Averaged within treatments, starch content of feces increased an average of 3 percent for every 1 unit drop in pH. The scatter of points was large, but the relationship was negative in all but one of the 12 corn-buffer combinations. This suggests a definite relationship of fecal pH and starch content, but failure of buffers to alter the two together questions whether this is a cause-effect relationship.

Table 7. Buffer additions, intake and feces composition

Additive	Lime	Dolo. lime	Bent.	LTM	Sodium bicarb	Low lime
Feed intake, lb dry matter	14.2	15.1	14.0	15.0	13.9	14.4
Fecal pH	6.54[b]	6.79[c]	6.55[b]	6.58[b]	6.53[b]	6.19[a]
Fecal starch, %	11.8	12.4	9.6	12.9	14.6	11.8
Fecal ash, %	8.5[a]	10.5[b]	14.6[c]	8.7[ab]	7.8[a]	8.0[a]

[abc]Means with different superscripts, differ statistically ($P<.05$).

Table 8. Buffer additions and digestibility

Additive	Lime	Dolo. lime	Bent.	LTM	Sodium bicarb.	Low lime
Dry matter, %	80.2	77.7	74.4	77.2	76.7	76.3
Starch, %	95.6	94.7	95.5	94.3	93.6	94.8
Protein, %	71.8[c]	66.0[ab]	62.6[a]	68.6[bc]	67.7[abc]	63.9[ab]

[abc]Means with different superscripts, differ statistically ($P< .05$).

Casual observation of fecal starch content with feed intake of individual steers revealed that within a corn-additive combination, high intakes markedly increased fecal starch. Additives or feeding systems which cause cattle to nibble rather than engorge feed and to reduce wide swings in feed intake should improve starch digestibility.

Literature Cited

Wheeler, W. E., and C. H. Noller. 1976. Limestone buffers in complete mixed rations for dairy cattle. J. Dairy Sci. 59:1788-1793.

Influence of Endosperm Type On the Nutritive Value Of Grain Sorghum and Corn

C. A. Hibberd, R. Schemm and D. G. Wagner

Story in Brief

The nutritive value of several varieties of grain sorghum and corn was studied utilizing *in vitro* dry matter disappearance and *in vitro* gas production procedures. IVDMD studies indicate that corn is the most digestible, white-bird resistant the least digestible and white-normal, hetero-yellow and waxy endosperm types intermediate in value. Moreover, hetero-yellow and waxy types appear superior to white-normal sorghum. Gas production studies indicate that white-bird resistant sorghum exhibits the lowest degree of starch availability. These studies demonstrate that there is a significant difference in digestibility of various grain varieties when dry, finely ground. Environmental conditions during the growing season may influence the nutritive value of sorghum, although this is not very clear.

Introduction

Improved utilization of grain sorghum as an energy source for ruminants has been of concern to beef producers for some time. Due to the prevailing water shortage and fuel costs in western portions of the Midwest and in the Southwest, grain producers are likely to be increasing sorghum production as a viable alternative to corn. This means more sorghum will likely be available for feeding.

Past research has generally shown that grain sorghum has a lower feeding value than corn. Several processing methods have been shown to enhance the digestibility of grain sorghum. Moreover, some research has shown that there is a difference in feeding value between various varieties of grain sorghum. Such studies indicate that it would be feasible to initiate sorghum breeding programs to improve the nutritive value of grain sorghum. Improved processing methods and genetic selection should permit more efficient utilization of sorghum. The purpose of this research was to investigate certain nutritive characteristics of several varieties of grain sorghum differing in endosperm type and corn.

Materials and Methods

Several grain sorghum varieties differing in endosperm type were grown at the Perkins Agronomy Research Station, and several varieties of corn were grown at the Panhandle Agronomy Research Station. All sorghum varieites were planted, grown and harvested under similar dryland conditions in two consecutive years. All corn varieties were planted, grown and harvested under similar irrigated conditions in the same two consecutive years. Varieties grown and the endosperm classification are illustrated in Tables 1 (Year I) and 2 (Year II). The grains were all finely ground through a 20 mesh screen prior to evaluation.

The chemical composition of the grains was determined using conventional procedures. *In vitro* dry matter disappearance (IVDMD) of the grains was determined utilizing strained rumen fluid inoculum. Percent dry matter disappearance was determined after 24 hr of incubation.

In vitro gas production was also utilized to determine the starch availability of the various grains. This method involves yeast fermentation of sugars released by enzyme attack on the starch. The ground sample, an enzyme solution (amyloglucosidase) and commercial baker's yeast were placed in Ehrlenmeyer flasks, connected to an inverted buret gas recovery system. The gas produced by the yeast during fermentation was measured as milliliters of gas per gram of dry sample. The more gas produced, the greater is the digestibility.

Results and Discussion

The chemical composition of the grains is illustrated in Tables 3 (Year I) and 4 (Year II). All of the sorghums were much higher in protein content than corn. Significant differences were obtained in both years. In general, the differences were small among the various sorghum endosperm types, but differences of 1.0 percent CP or more did exist. Figure 1 illustrates the IVDMD trends for the Year I crop. Corn had a significantly higher IVDMD ($P<.05$) than the sorghums. Dry, finely ground white-bird resistant sorghum was much more poorly digested ($P<.05$), and the waxy, white-normal and hetero-yellow endosperm types were intermediate in value. The data also illustrate that waxy sorghum tends to be the most digestible, although the difference was not significant at the .05 level.

IVDMD values for the second crop are illustrated in Figure 2. Similar trends as noted in Year I were observed. Corn was significantly more digestible ($P<.05$) than all the sorghum endosperm types. Among the sorghums, white-bird resistant was again significantly lower ($P<.05$) than all the others, and white-normal, hetero-yellow and waxy were intermediate in value. The white-normal endosperm was significantly lower ($P<.05$) than hetero-yellow and waxy types, indicating that this endosperm type is less desirable than either the hetero-yellow or waxy type.

In general, *in vitro* gas production studies also showed the white bird resistant endosperm type to have the lower starch availability in both years. The high tannin content of the bird resistant varieties of grain sorghum may hinder starch digestibility.

Table 1. Descriptive characteristics and classification of the grains (Year I)

Variety	Seed coat color	Endosperm			Classification
		Color	Hardness	Waxy or normal	
Pioneer corn 3149	Colorless	Yellow-corn	Yellow dent corn	Normal	Corn
Pioneer corn 3306	Colorless	Yellow-corn	Yellow dent corn	Normal	
Darset (bird resistant)	Brown	White	Intermediate	Normal	White-BR
Soft endo	Brown	White	Soft	Normal	White-normal
Redlan normal	Red	White	Intermediate	Normal	
OK 612	Red	Hetero-yellow	Intermediate	Normal	Hetero-yellow
Dwarf redlan	Red	White	Intermediate	Waxy	Waxy

Table 2. Descriptive characteristics and classification of the grains (Year 2)

Variety	Seed coat color	Endosperm			Classification
		Color	Hardness	Waxy or normal	
Pioneer corn	Colorless	Yellow corn	Yellow dent corn	Normal	Corn
Northrup king corn	Colorless	Yellow corn	Yellow dent corn	Normal	
Darset (bird resistant)	Brown	White	Intermediate	Normal	White-BR
Soft endo	Brown	White	Soft	Normal	White-normal
Redlan Normal	Red	White	Intermediate	Normal	
OK 612	Red	Hetero-yellow	Intermediate	Normal	Hetero-yellow
Dwarf redlan	Red	White	Intermediate	Waxy	Waxy
73BCT 1126	White	Yellow	Intermediate	Waxy	
73BCT 1133-2	Brown	Yellow	Intermediate	Waxy	
733CT 1122-2	Red	Yellow	Intermediate	Waxy	

Table 3. Whole grain composition[a] (Year I)

Endosperm type	Percentage		
	Protein	Ether extract	Ash
Corn	9.56[a]	5.36	1.70
White-BR	12.80[b]	3.28	1.36
Waxy	13.12[b]	1.27	1.90
Hetero-yellow	12.90[b]	2.00	1.19
White-normal	14.26[b]	1.30	2.14

[a]Dry matter basis

Table 4. Whole grain composition[a] (Year II)

Endosperm type	Percentage		
	Protein	Ether Extract	Ash
Corn	9.40[a]	6.72	1.73
White-BR	12.02[b,c]	4.24	2.18
Waxy	13.54[b]	5.08	2.78
Hetero-yellow	11.61[c]	4.04	1.98
White-normal	11.48[a,b,c]	5.48	2.25

[a]Dry matter basis

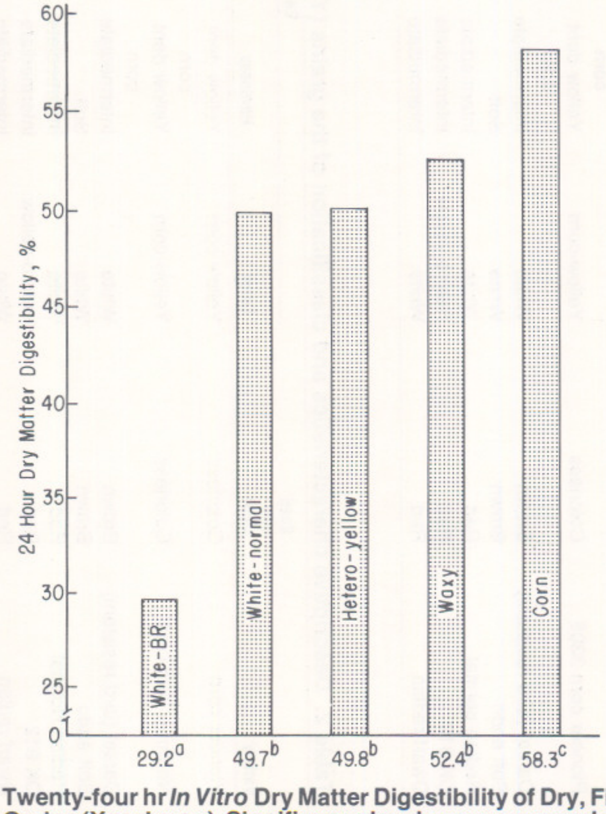

Figure 1. Twenty-four hr *In Vitro* Dry Matter Digestibility of Dry, Finely Ground Grains (Year I crop). Significance levels are expressed at .05 levels.

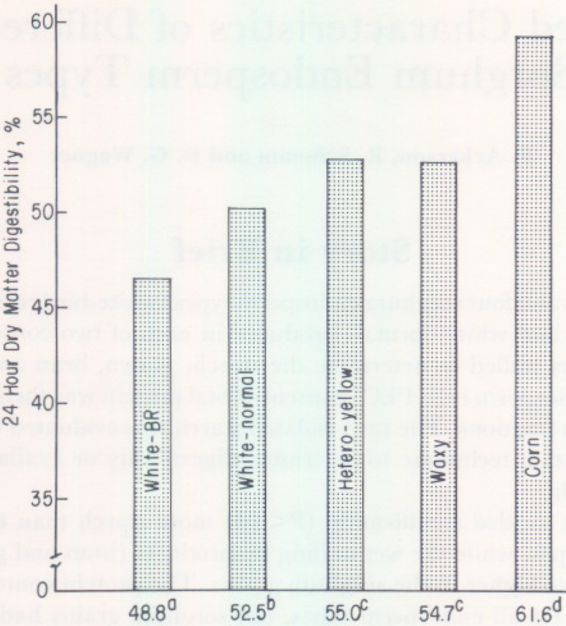

Figure 2. Twenty-four hr *In Vitro* Dry Matter Digestibility of Dry, Finely Ground Grains (Year 2 Crop). Significance levels are expressed at .05 level.

The gas production and IVDMD values, in general, were higher for all sorghum during the second year, indicating possible environmental effects on digestibility. Average rainfall during the growing season in Year I was about 1 inch below normal, but also 1.26 inches above normal during the second year. Environmental effects are not well understood.

Seed Characteristics of Different Sorghum Endosperm Types

B. Ackerson, R. Schemm and D. G. Wagner

Story in Brief

One corn and four sorghum endosperm types (white-bird resistant, waxy, hetero-yellow and white normal) produced in each of two consecutive crop years were wet milled to determine the starch, gluten, bran and germ and peripheral endosperm cell (PEC) content. Total protein was then determined on the various fractions. The raw, isolated starch was evaluated by an *in vitro* ruminal digestion technique to determine digestibility or availability of the purified starch.

The corn yielded significantly ($P<.05$) more starch than the sorghum endosperm types, while the wet milling by-products (bran and germ, gluten and PEC) were higher in the sorghum grains. The protein content in starch was very low for all endosperm types, but sorghum grains had the highest protein content in the other wet milling fractions. The PEC fraction, which makes up the protein matrix, averaged 5.4 percent higher in protein content for sorghum as compared to corn. Since starch granules are embedded in the protein matrix, the higher protein content of the PEC fraction of sorghums may suggest more total protein matrix. Moreover, there may be a lower solubility of the proteinaceous matrix. Thus, starch would be less easily released in sorghums as compared to corn. This, in addition to a lower starch content, may explain, at least partially, the reduced feeding value of sorghums compared to corn. *In vitro* data on the isolated, purified starch provided evidence that starch alone is not entirely responsible for the lower feeding value of sorghum as differences among the five endosperm types were small and not significant ($P>.05$).

Introduction

The major expense in cattle finishing rations is the cereal grain which supplies the major energy source. Since cereal grains contain much starch, efficiency of starch utilization is of utmost importance.

Previous research has indicated a lower feeding value for sorghum grain as compared to corn or barley, although chemical compositions of the grains are rather similar. This might be partly attributed to plant genetics as past emphasis in sorghum breeding has been on agronomic traits such as drought, bird and insect resistance rather than nutritive value. Thus, sorghum grains are much more variable and usually lower in feeding value than the other cereal grains. Past research has been largely based upon nondescript or common sorghum varieties. Sorghum grain varieties with superior feeding value likely exist.

The purpose of this study was to compare the grain composition of several varieties of sorghum grain with corn. Moreover, susceptibility of the isolated sorghum starches to ruminal bacterial digestion was determined.

Materials and Methods

Wet milling

Five sorghum varieties in Year I and eight sorghum varieties in Year II were planted on irrigated land at the Perkins Agronomy Research Station. These varieties represented four sorghum endosperm types (white-bird resistant, waxy, hetero-yellow and white normal) each year. In addition, two hybrid corn varieties were planted and managed under similar conditions on irrigated land at the Panhandle Agronomy Research Station.

A 300 g sample of air dried grain was subjected to two steeping solutions consisting of sulfur dioxide and lactic acid for a total of 48 hr after which the solution was drained. The purpose of the steeping solutions was to soften the protein matrix in which the starch is embedded to facilitate the release of starch during the milling process. The milling process consisted of grinding the steeped grain with distilled water in a Waring Blender with the blades reversed to reduce damage to the starch granule. The slurry was then poured over three sieves which separated the grain into four components—bran and germ, gluten, peripheral endosperm cells and a starch and gluten mixture which passed through the sieves. The bran and germ portion represents the seed coat and embryo of the grain, while the gluten and peripheral endosperm cell fraction represents the protein matrix. The starch and gluten mixture was separated by pouring the solution onto a starch table which consisted of a long aluminum trough. The starch, being denser, settled on the table while the lighter gluten flowed off the end of the table when washed with distilled water. The gluten was then separated from the water by centrifuging. The starch was washed with distilled water and allowed to dry to a solid, white cake. It was then scraped off the table and dried in a 40 C oven for 48 hr and weighed. The gluten, bran and germ and peripheral endosperm cell fractions were dried in a 100 C oven for 24 hr and weighed.

In Vitro Ruminal Dry Matter Disappearance of Isolated Starch

A 0.2 g starch sample (dry matter basis) was evaluated for *in vitro* digestion by ruminal microorganisms. Twenty milligrams of urea was added to each tube to elevate the nitrogen level to approximately that found in intact grain. Each tube was inoculated with a mixture of artificial saliva and rumen fluid which was obtained from a fistulated steer being fed a high concentrate diet. *In vitro* dry matter disappearance (IVDMD) was determined for a 24 hr incubation (digestion) period.

Results and Discussion

Wet milling

Table 1 shows how the Year I sorghum varieties were classified into different endosperm types. The sorghum grains were grouped in this way because of the large number of varieties that have been developed, and varieties of a common endosperm type should be more alike than varieties of different endosperm types. This system of classification should allow for a wider application of the data from this study, providing the endosperm type of a variety is known.

The wet milling composition of the Year I grains is shown in Table 2. Corn consisted of 64.9 percent starch and was significantly ($P<.05$) higher than any of the sorghum endosperm types, which averaged 57 percent starch. The wet milling by-products (bran and germ, gluten and peripheral endosperm cells) were higher in the sorghum grains than in the corn. Though not significant, there was a trend for the waxy sorghum endosperm type to be higher in starch and lower in bran and germ and peripheral endosperm cells than the other sorghum endosperm types. Since the sorghum endosperm types contained an average of 7.9 percent less starch than the corn, this can explain (at least partially) why sorghum grains may be somewhat lower in feeding value than corn.

The protein content of the various wet milling fractions is shown in Table 3 for the Year I crop. Starch contains only very minute quantities of protein while the other fractions are considerably higher. The protein content of the corn bran and germ (9.9 percent) was much lower than the sorghum endosperm types which averaged 16.8 percent. The peripheral endosperm cell fraction of sorghum grains contained 5.4 percent more protein than the corn. Since the peripheral endosperm cell fraction makes up the protein matrix, the increased protein found in this fraction may be related to the quantity and solubility of the protein matrix and the subsequent release of the starch granules.

In the Year II crop, the same endosperm types were represented. The only variety changes were in the corn and waxy endosperm types. The corns consisted of Northrup King and Pioneer while the waxy endosperm type consisted of 73BCT 1126, 73BCT 1133-2, 73BCT 1122-2 and Dwarf Redlan varieties. The wet milling data for the Year II crop showed the same trends observed in the first crop.

IVDMD of isolated starch

The 24 hr IVDMD values on the Year I raw, isolated starches, grouped according to endosperm type, are shown in Figure 1. Although differences in dry matter digestibilities were small and not significant ($P>.05$) among endosperm types, waxy starch was slightly more digestible (60.8 percent) than the others (avg. 57.8 percent). The same trend was observed in the second

Table 1. Year 1 sorghum variety classification

Variety	Endosperm type classification
Pioneer corn 3149	Corn
Pioneer corn 3306	Corn
Darset (bird resistant)	White-BR
Soft endo	White-normal
Redlan normal	White-normal
OK 612	Hetero-yellow
Dwarf redlan	Waxy

Table 2. Wet milling compositional characteristics of grains[a] (Year I)

Endosperm type	Percentage			
	Starch	Bran and germ	PEC[b]	Gluten
Corn	64.9[a]	15.0[a]	1.1[a]	7.7[a]
Waxy	59.5[b]	16.0[a,b]	3.0[b]	10.9[b,c]
White-BR	54.9[c]	17.7[b,c]	4.4[c]	12.2[d]
Hetero-yellow	58.9[b]	16.4[a,b]	5.1[c]	10.6[b]
White-normal	54.9[c]	18.4[c]	5.1[c]	11.6[c,d]

[a]Dry matter basis.
[b]Peripheral endosperm cells.
[a,b,c,d]Means in a column with different superscripts are significantly different ($P<.05$).

Table 3. Protein content[a] of wet milling fractions (Year I)

Endosperm	Percentage			
	Starch	Bran and germ	Peripheral endosperm cells	Gluten
Corn	.30	9.90	18.76	47.69
White-BR	.31	16.41	23.80	37.63
Waxy	.23	17.12	27.32	51.61
Hetero-yellow	.36	16.48	20.42	46.32
White normal	.36	17.20	25.15	49.06

[a]Dry matter basis.
[b]Protein content of the whole grain is: 9.56% (corn), 12.80% (white-BR), 13.12% (waxy), 12.90% (hetero-yellow), 14.26% (white-normal).

crop. This data suggests that starch type alone cannot account for much of the difference in corn and sorghum digestibilites. Gas production data (susceptibility of starch to purified enzyme attack) provides additional evidence in that the waxy sorghum starch was more susceptible to enzymatic attack than the other endosperm types.

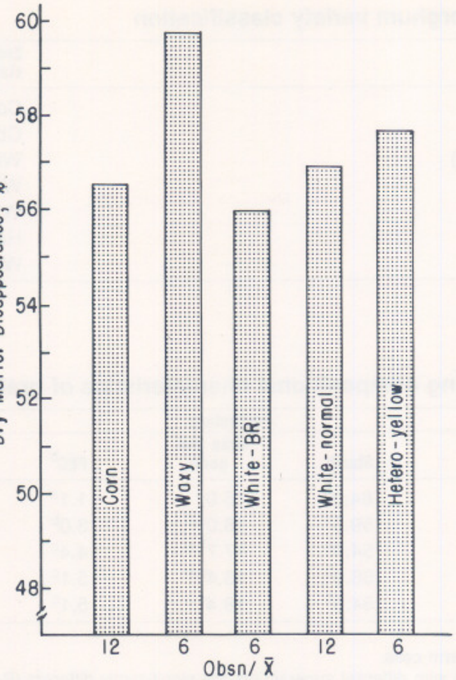

Figure 1. 24 Hour IVDMD of Raw, Isolated Starch (Year I Crop)

The lower feeding value of sorghum grains as compared to corn seems to be related to a lower starch content and the chemical and/or structural composition of the protein matrix which surrounds the starch granules. Once the sorghum starch is released from the proteinaceous matrix, it appears to be rather comparable in value to raw, isolated corn starch.

Protein Levels and Decline for Finishing Steers Fed High Moisture Corn

J. J. Martin, F. N. Owens, D. R. Gill, J. H. Thornton and D. E. Williams

Story in Brief

One hundred eighty-six steers were grouped and fed four protein levels (9, 11, 13 and declining over time) and two Rumensin levels (0 and 30 g/ton) with high moisture corn for 166 and 194 days. Rumensin improved efficiency of feed use by 3.2 percent, mainly during the first 56 days. Rates of gain and feed efficiency favored the 13 percent ration, especially early in the trial, but economics would favor either a continuous 11 percent protein ration or a system of 13 percent protein for steers to 700 lb, 11 percent to 850 lb and 9 percent protein thereafter.

Introduction

Previous work has suggested that protein level in dry corn rations may be reduced when Rumensin is added (Gill *et al.*, 1977). Decreasing the level of supplemental protein in dry corn rations as steers mature may reduce cost of gain if performance is only slightly reduced. A given amount of protein should be more useful if fed early than late in the finishing period, and declining levels should match protein needs more economically than a constant level. But protein levels, sources and decline with high moisture corn rations have received little attention. This experiment conducted at Panhandle State University, Goodwell, Okla., was designed to examine the effects of protein level or withdrawl and Rumensin presence on performance and carcass characteristics of steers fed a high moisture corn-corn silage ration.

Materials and Methods

One hundred ninety-two steers were divided by weight group (mean shrunk weights of 420, 481 and 539 lb) and allotted to 24 pens. The ration and experimental methods were identical with the trial reported by Gill *et al.*, elsewhere in this publication. These two experiments had six treatments in common. Steers withdrawn from protein were fed the 13 percent protein ration the first 56 days (to a mean weight of 673 lb), the 11 percent protein ration for the next 56 days (to a mean weight of 864 lb) and the 9 percent protein ration containing no added soybean meal to slaughter.

Results and Discussion

Weight grouping had a considerable impact on feed intake throughout the trial, on feed efficiency early in the trial, on carcass weight, on daily gain (heavier initial weights gaining more rapidly), on marbling score and grade and on carcass age. Part of this difference is attributable to slaughter of the two heavier weight groups at 166 days and the lighter group at 194 days on feed. This effect of weight group was removed statistically. As no measurements showed evidence of an interaction of protein level and Rumensin, these two factors will be presented separately.

Rumensin effects

Rumensin effects on performance and carcasses are shown in Tables 1 and 2. Overall feed intake was reduced by 4 percent with Rumensin feeding while gains were decreased by 0.9 percent. This improved feed efficiency by 3.2 percent, most of which was achieved the first 56 days of the experiment.

The first 28 days, Rumensin fed cattle had 10 percent more rapid weight gain, but this weight difference declined over time so that no liveweight difference was apparent at slaughter. Indeed, final weight adjusted to a

Table 1. Rumensin and steer performance

Item	Rumensin Level 0	Rumensin Level 30
Steers, number	92	94
Initial weight, lb	483	484
Weight, lb/day		
0-56 days	3.09	3.13
56+	3.28	3.22
Total	3.22	3.19
Feed intake, lb/day		
0-56 days	14.2	13.7
56+	19.2[a]	18.4[b]
Total	17.6[a]	16.9[b]
Feed per gain		
0-56 days	4.67[a]	4.45[b]
56+	5.87	5.72
Total	5.48[a]	5.31[b]
Carcass daily gain		
Protein, lb	.244	.239
Fat, lb	1.05	1.05
Energy, mcal	5.11	5.10
Pounds	2.20	2.18
Caloric efficiency		
kcal stored/lb feed	289	302

[a,b]Means in a row which have different superscripts differ statistically.

Table 2. Rumensin and carcass characteristics of finishing steers

Item	Rumensin level 0	Rumensin level 30
Carcass weight, lb	649	646
Liver abscesses, %	13	16
KHP fat, %	3.1	3.0
Fat thickness, in	0.65	0.64
Marbling score[a]	14.0	13.8
Ribeye area		
square inches	12.3	12.3
in. ^{2}/cwt carcass	1.90	1.91
Quality grade[b]	13.7	13.5
Color[d]	5.8	5.7
Age[e]	1.9	1.8
Cooler shrink, %	1.18	1.05
Carcass composition,		
Protein, %	14.6	14.6
Fat, %	33.2	33.3
kcal/g	3.92	3.93

[a]Small minus = 13, small = 14, small plus = 15.
[b]Good plus = 13, choice minus = 14.
[c]Cherry red = 6, slightly dark red = 5.

constant dressing percentage gave the control cattle a slight advantage. Since interval weights were taken on a full basis, and steers were not shrunk, greater gut fill with Rumensin feeding may be responsible for these trends over time. Carcass characteristics (Table 2) were unchanged by Rumensin feeding.

Protein level and decline

Protein level and decline effects are presented in Table 3. The 9 percent protein level was obviously deficient for the steers. During the first 84 days on feed, this group continued to fall behind the other groups and thereafter the difference stabilized. The steers fed 11 percent protein lagged behind the 13 percent protein group for the first 56 days but tended to compensate during the rest of the trial. Steers fed declining protein levels paralleled the gain of the 13 percent group during the trial but fell just slightly behind the last 56 days when fed 9 percent protein.

Feed efficiencies were good on all treatments. Steers fed 13 percent protein had the most favorable feed efficiency, about 10 percent superior to steers fed the 9 percent protein ration. Feed efficiency differences paralleled weight gains, with differences being noted primarily during the first 56 days on

Table 3. Performance of finishing steers across protein levels

Item	Protein Concentration, percentage			
	9	11	13	13-11-9
Steers, number	47	48	45	46
In weight, lb	483	483	484	483
Weight gain, lb/day				
0-56 days	2.48[a]	3.11[b]	3.44[b]	3.40[b]
56+	3.25	3.34	3.25	3.15
Total	3.01[a]	3.27[b]	3.31[b]	3.24[b]
Feed intake, lb/day				
0-56 days	13.7	14.1	13.9	14.1
56+	19.0	19.0	18.5	18.7
Total	17.3	17.4	17.1	17.2
Feed per gain				
0-56 days	5.54[c]	4.54[b]	4.05[a]	4.14[a]
56+	5.85	5.69	5.71	5.92
Total	5.76[c]	5.34[b]	5.15[c]	5.31[bc]
Feed/gain improvement with rumensin, %	0.7	5.4	4.2	2.4
Carcass daily gain				
Protein, lb	0.240	0.233	0.246	0.247
Fat, lb	0.99	1.14	1.07	1.01
Energy, mcal	4.84	5.46	5.17	4.96
Pounds	2.07[a]	2.23[b]	2.25[b]	2.21[b]
Caloric efficiency kcal stored/ lb feed	279[a]	312[b]	303[ab]	288[a]

[a,b,c]Means in a row which have different superscripts differ statistically.

trial with mean weights under 680 lb. This suggests that with high moisture corn based rations, protein levels above 11 percent are needed to maximize gain and efficiency for steers of English breeding under 700 lb. A decline to 11 percent protein at 700 lb appears feasible and a drop to 9 percent at 850 lb may not have a deleterious effect on gain and feed efficiency. Since the cattle fed 11 percent protein made greater compensatory gain from 56 days to slaughter than those fed 9 percent protein, this suggests that previous protein status also may influence need for protein during the later phases of finishing. Moderate protein levels should permit compensatory performance whereas marginal levels may not.

Carcass characteristics of steers fed various protein levels are shown in Table 4. Carcass weight and fat thickness over the rib were lower for steers fed the 9 percent protein ration. Fat thickness and kidney-heart and pelvic fat also appeared slightly reduced with the declining protein treatment. This would suggest that lower levels of protein during later stages of finishing may decrease fat cover and possibly marbling as well.

Economic analysis of the value of soybean meal supplementation to increase protein content of the ration is shown in Table 5. The value of added soybean meal increases with overhead cost, and corn price. The value of adding soybean meal should generally justify its addition to a level of 11 percent protein or to the declining protein levels. But adding soybean meal to

Table 4. Carcass characteristics of finishing steers across protein levels

	Protein Concentration			
Item	**9**	**11**	**13**	**13-11-9**
Carcass weight, lb	626[a]	654[b]	659[b]	652[b]
Liver abcess, %	12	4	23	19
KHP fat, %	3.0	3.1	3.1	2.9
Fat thickness, inc.	.58[a]	.69[b]	.68[b]	.62[ab]
Marbling score[c]	13.7	14.6	14.0	13.3
Ribeye area				
square in	12.0	12.3	12.6	12.2
square in/100 lb carcass	1.92	1.89	1.92	1.88
Quality grade[d]	13.5[a]	13.9[b]	13.6[a]	13.4[b]
Color[e]	5.7	5.8	6.0	5.5
Age[f]	1.8	1.8	1.9	1.9
Cooler shrink, %	1.15	1.11	1.04	1.18
Carcass composition				
Protein, %	14.9	14.2	14.6	14.8
Fat, %	32.3	35.0	33.4	32.4
kcal/g	3.84	4.07	3.94	3.85

[a,b]Means in a row which have different superscripts differ statistically.
[c]Small minus = 13, small = 14, small plus = 15.
[d]Good plus = 13, choice minus = 14.
[e]Cherry red = 6, slightly dark red = 5.
[f]A minus = 1, A = 2.

Table 5. Economic analysis of protein levels for finishing steers

Item		Protein level, percentage of dry matter 9	11	13	13-11-9
Daily gain		3.01	3.27	3.31	3.24
Days/cwt gain		33.27	30.60	30.21	30.87
Overhead/cwt gain					
@ 30¢/day		9.98	9.18	9.06	9.26
Feed/cwt gain					
Total lb		576.4	534.3	515.4	531.2
Non-soybean meal		576.4	514.9	470.6	512.6
Soybean meal lb		0	19.4	44.8	18.6
Basal ration costs/cwt gain					
5¢/lb		28.82	25.74	23.53	25.63
6¢/lb		34.58	30.89	28.24	30.76
Total cost/cwt gain excluding soybean meal					
Overhead	*Feed*				
0	5¢/lb	28.82	25.74	23.53	25.63
0	6¢/lb	34.58	30.89	28.24	30.76
30¢/day	5¢/lb	38.80	34.92	32.59	34.89
30¢/day	6¢/lb	44.56	40.07	37.30	40.02
Value of added soybean meal $ per ton @ 90% dry matter		Protein level changes			
Overhead	*Feed*	9→ 11%	11→ 13%	9→ Variable protein	
0	5¢/lb	$286	$157	$309	
0	6¢/lb	$342	$188	$370	
30¢/day	5¢/lb	$360	$165	$378	
30¢/day	6¢/lb	$417	$196	$439	

increase protein from 11 to 13 percent often would prove non-economic despite a potential improvement in feed efficiency. The protein level which maximizes steer gain or efficiency may not be the most economical to feed. The declining protein levels proved most economical as less total protein was used. Feed intake was lower early in the finishing period when protein content was highest. Declining protein levels with dry corn rations worked well last year as well (Martin *et al.*, 1977). Adjusting the protein level to maximize economic return should prove rewarding. More steer performance trials with various protein levels, sources and corn processing methods are needed to refine these economic models.

Literature Cited

Gill, D. R., F. N. Owens, J. J. Martin, D. E. Williams and J. H. Thornton. 1977. Protein levels and Rumensin for feedlot cattle. Agric. Exp. Sta., Okla. State Univ., Misc. Pub. MP-101:42.

Martin, J. J., F. N. Owens, D. R. Gill and J. H. Thornton. 1977. Protein sources and Rumensin for feedlot steers. Okla. Agric. Res. Rep. 101:47.

Rumensin Levels for Finishing Steers Fed High Moisture Corn

D. R. Gill, F. N. Owens, J. J. Martin, J. H. Thornton and D. E. Williams

Story in Brief

Three Rumensin levels (0, 15 and 30 g per ton) at three protein levels (9, 11 and 13 percent of ration dry matter) were fed in 187 finishing steers for 166 to 194 days at Panhandle State University, Goodwell, Oklahoma. The high moisture corn-corn silage rations were supplemented with soybean meal in all cases. The two higher protein levels improved rate of gain and feed efficiency for the trial, but benefits were apparent mainly at weights over 700 lb. Rumensin improved feed efficiency by 3.0 percent. Improvement in feed efficiency was almost as large at the 15 level of Rumensin as it was with 30 g in this trial. Rumensin proved most useful with higher protein concentrations.

Introduction

Rumensin is commonly fed to finishing cattle in feedlots of the Great Plains. It is approved for feeding to cattle in confinement at levels from 5 to 30 g per ton of feed. At lower levels, Rumensin may increase rate of gain, but higher levels are needed to maximize feed efficiency. This trade-off, between rate of gain and feed efficiency, may make lower Rumensin levels more economical when non-feed costs are high and feed cost is low. This feedlot study was conducted to determine the effects of feeding Rumensin at 0, 15 or 30 g per ton with ration proteins at 9, 11 and 13 percent of the ration dry matter.

Materials and Methods

One hundred ninety-two steers with a mean shrunk weight of 483 lb were allotted to 24 pens. There were three replications on each protein level at 0 and 30 Rumensin and two replications on each protein level at the 15 g level. Five steers did not complete the trial for health reasons not associated with ration treatments. The high moisture corn-corn silage ration (Table 1) was freely available and intake records were maintained. Steers were implanted initially with 24 mg diethylstilbestrol and after 84 days on feed with Synovex S. Each 28 days steers were weighed without shrink. Cattle were fed either 164 or 196 days as they were slaughtered as they reached apparent grade; carcass characteristics were measured. Final weight was calculated from hot carcass weight using a mean dressing percentage of 62 percent to adjust for differences in fill. Specific gravities, based upon carcass weight underwater, were used to esti-

Table 1. Feed compositon of test rations

Ingredient	Protein Percentage 9	11	13
	Percent of Dry Matter		
High moisture corn grain	75.2	75.2	75.2
Corn silage	14.0	14.0	14.0
Alfalfa meal	0.50	0.50	0.50
Dry ground corn	8.28	4.85	0.0
Soybean meal	0.0	3.62	8.70
Limestone	1.10	1.12	1.07
KCl	0.47	0.34	0.16
Salt	0.30	0.30	0.30
Vitamin A	+	+	+
Trace mineral	+	+	+
Rumensin	±	±	±

mate percentage protein and fat and energy content of 10 steers at the start of the trial and of 107 finished steers at slaughter. Daily protein, fat and energy gains were calculated.

Results and Discussion

A whole shelled corn-cottonseed hull ration was fed last year to a similar set of steers (Gill *et al.*, 1977). In that trial, Rumensin proved most effective at a low protein level. Results with the high moisture ration fed this year showed no apparent interaction, so results of protein and Rumensin levels will be presented separately.

Protein concentration effects

Protein concentration effects on performance data are shown in Table 2. Data is divided into periods of early (0 to 56 days) and later (56 days to slaughter) performance. High protein levels proved most beneficial early in the feeding period, and markedly improved rate of gain and feed efficiency during this period. Rate of gain favored the 13 percent protein ration during the first 56 days (to 660 lb) and the 11 percent ration in subsequent periods. Feed efficiency also favored the 13 percent ration throughout the trial. These early effects of higher protein levels on rate and efficiency of gain were diluted later in the trial, but an overall benefit was maintained. Carcass characteristics of these steers are presented in Table 3. The differences noted in fat thickness over the rib and rib eye area are probably the result of the differences in carcass weight. Indeed, rib eye area, expressed on a basis of inches per 100 lb of carcass, was unchanged by protein level. However, increased carcass fat with higher protein levels and slightly decreased marbling with higher protein levels, as suggested by other studies, are trends which may be gleaned from these results. Level of protein feeding did not influence protein or fat percentage of the carcass.

Table 2. Performance of finishing steers fed three protein levels

Item	Protein Concentration		
	9	11	13
Steers, number	62	64	61
Initial weight, lb	482	483	483
Weight gain, lb/day			
0-56 days	2.48[a]	3.17[ab]	3.46[b]
56-slaughter	3.20	3.31	3.29
Total	2.97[a]	3.27[b]	3.35[b]
Feedintake, lb/day			
0-56 days	13.6	14.3	14.0
56-slaughter	18.7	18.9	18.6
Total	17.1	17.4	17.2
Feed per gain			
0-56 days	5.53[a]	4.50[b]	4.07[c]
56-slaughter	5.85	5.71	5.65
Total	5.76[a]	5.34[b]	5.12[c]

[a,b,c]Means in a row which have different superscripts differ statistically.

Table 3. Carcass characteristics of finishing steers fed three protein levels

Item	Protein Concentration[a]		
	9	11	13
Carcass weight, lb	630	656	665
Liver abcess, %	29[a]	16[a]	20[b]
KHP fat, %	3.1	3.1	3.1
Fat thickness, in	0.62[c]	0.71[b]	0.69[bc]
Marbling score[d]	14.1	14.5	13.9
Ribeye area			
square in	11.9[c]	12.4[bc]	12.6[b]
square in/100 lb carcass	1.90	1.90	1.90
Quality grade[e]	13.7	14.0	13.6
Color[f]	5.8	5.8	5.9
Age[g]	1.8	1.9	1.9

[a]Percentage of ration dry matter.
[b,c]Means in a row which have different superscripts differ statistically.
[d]Small minus = 13, small = 14, small plus = 15.
[e]Good plus = 13, choice minus = 14.
[f]Cherry red = 6, slightly dark red = 5.
[g]A minus = 1, A = 2.

Rumensin concentration effects

Rumensin concentration effects on steer performance data are presented in Table 4. As review of literature (Thornton, 1976) would suggest, rate of weight gain may be slightly increased at low but depressed by higher Rumensin concentrations. Feed intake depression and feed efficiency improvements with Rumensin were apparent. But as has been common in our trials, improvement in feed efficiency was lower (3.0 percent) than is commonly reported. This lower response may be associated with (1) high animal performance making percentage improvement more difficult, (2) the very high concentrate rations, typical of Great Plains Feedlots being fed, (3) use of fermented feeds which may respond less to Rumensin and (4) correcting animal performance to a carcass weight basis, thereby avoiding differences in fill.

Feed efficiency in this study was similar with either 15 or 30 g Rumensin feeding. Some literature (Elanco, 1975) would suggest that feed efficiency may be greater at 30 g per ton than at lower levels. The difference with this trial may be due to the above four factors. Feed intake was more depressed by Rumensin after 56 days on feed. Possibly reducing its level for steers with higher intakes may prove helpful. Efficiency of carcass energy deposition was greater for steers fed 15 g per ton than other levels. Rumensin did not alter carcass characteristics (Table 5) except that fat and energy content of steers fed Rumensin at 15 g/ton was slightly greater than of those fed 0 or 30 g per ton. Liver abscess incidence was not increased by higher Rumensin and higher protein levels in this study as was noted with dry shelled corn rations in 1977 (Gill *et al.*, 1977).

Caution should be exercised in application of results of this trial to other feeding conditions. Although the 30 g per ton Rumensin concentration may not be the most economical level under all conditions of feed and overhead

Table 4. Performance of finishing steers at three rumensin levels

Item	Rumensin Concentration		
	0	15	30
Steers, number	69	47	71
In weight, lb	483	481	484
Weight gain, lb/day			
0-56 days	2.98	3.12	3.04
56+	3.33	3.23	3.24
Total	3.22	3.20	3.17
Feed intake, lb/day			
0-56 days	14.2	14.2	13.7
56+	19.4	18.3	18.4
Total	17.7	17.1	16.8
Feed per gain			
0-56 days	4.83	4.67	4.59
56+	5.83	5.69	5.68
Total	5.51[a]	5.36[b]	5.33[b]
Carcass daily gain			
Protein, lb	0.24	0.25	0.234
Fat, lb	1.07	1.18	1.06
Energy, mcal	5.16	5.69	5.15
Pounds	2.20	2.17	2.17
Caloric efficiency			
kcal stored per lb of feed	290[a]	333[b]	305[ab]

[a,b]Means in a row which have different superscripts differ statistically.

Table 5. Carcass characteristics of steers fed three rumensin concentrations

Item	Rumensin Concentration		
	0	15	30
Carcass weight, lb	648	663	644
Liver abcess, %	14	8	12
KHP fat, %	3.1	3.1	3.1
Fat thickness, in	0.65	0.72	0.65
Marbling score[c]	14.4	14.5	13.8
Ribeye area, in^2	12.3	12.2	12.3
Quality grade[d]	13.9	13.9	13.5
Color[e]	5.9	6.0	5.8
Age[f]	1.9	1.9	1.8
Cooler shrink, %	1.16	1.05	1.04
Carcass composition			
Protein, %	14.6	14.1	14.6
Fat, %	33.6	35.6	33.5
kcal/g	3.95	4.12	3.94

[a,b]Means in a row which have different superscripts differ statistically.
[c]Small minus = 13, small, = 14, small plus = 15.
[d]Good plus = 13, choice minus = 14.
[e]Cherry red = 6, slightly dark red = 5.
[f]A minus = 1, A = 2.

costs as review of the literature suggests (Thornton, 1977) other ration and economic factors (Gill, 1974) need consideration. When greater amounts of roughage are fed, higher Rumensin levels appear useful. Further, this experiment was calculated on a *carcass weight* basis. If cattle are sold on a live-weight rather than a grade-and-yield basis, and Rumensin increases gut fill and reduces dressing percentage slightly, this would alter interpretation of the test results. The data also suggests that cooler shrink on the Rumensin cattle may be less than the control cattle (Table 5). The overall economic benefit of Rumensin feeding to finishing cattle, consistently reported by experiment stations across the nation, is supported by results of this trial. However, results question whether the 30 g per ton level is most economical under all feedlot conditions.

Protein-Rumensin interactions

The interaction observed with a dry corn-cottonseed hullration last year, in which Rumensin spared protein, was not observed in this trial. Efficiency and gain comparisons by protein and Rumensin level are presented in Table 6. With these high moisture corn rations, Rumensin depressed gain slightly at a low protein level. Opposite from effects with dry corn last year, Rumensin proved most useful in improving feed efficiency with higher protein levels. The reason for a Rumensin-protein corn moisture interaction may be associated with differences in either 1) starch avilability or 2) protein quality of the corn. A digestion trial with these rations currently is underway to help answer this question.

Table 6. Rumensin-protein interaction

Rumensin level	Protein level 9	11	13
g/ton		Daily gain	
0	3.06	3.28	3.32
15	2.87[c]	3.26[cd]	3.47[d]
30	2.96	3.26	3.30
		Feed/gain	
0	5.78[c]	5.49[ad]	5.26[de]
15	5.75[c]	5.32[abd]	5.03[e]
30	5.74[c]	5.19[bd]	5.04[d]

[ab]Means in a *column* which have a different superscript differ statistically.
[cde]Means in a *row* which have a different superscript differ statistically.

Literature Cited

Elanco, 1975. Rumensin Technical Manual, Eli Lilly and Company, Indianapolis, Indiana.

Gill, Donald. 1974. What are reasonable costs of gain? Oklahoma Cattle Feeders Seminar.

Gill, D. R., F. N. Owens, J. J. Martin, D. E. Williams and J. H. Thornton. 1977. Protein levels and Rumensin for feedlot cattle. Agric. Exp. Sta., Okla. State Univ. Misc. Pub. MP-101:42.

Thornton, J. H. 1976. Effects of monensin on various types of rations fed in the Oklahoma Panhandle. Oklahoma Panhandle Feeders Day Report.

BEEF CATTLE BREEDING

Carcass Evaluation of Certain Two-Breed Cross Steers

M. E. Boyd, R. R. Frahm,
L. E. Walters and L. Kimbrell

Story in Brief

Slaughter and carcass data were analyzed on 269 crossbred steers obtained by mating Hereford (H), Angus (A), Simmental (S), Brown Swiss (B) and Jersey(J) bulls to Hereford and Angus cows. The steers were individually slaughtered as an anticipated low choice carcass grade had been attained. Brown Swiss and Simmental cross steers required 17 more days in the feedlot and were heaviest at slaughter (1110 lb). HA steers weighed 1034 lb and Jersey cross steers weighed 915 lb at slaughter. Jersey cross steers had a 1.5 percent lower dressing percentage than the other crossbred groups. All crossbred groups had sufficient marbling to grade choice, however Jersey cross steers received 1/6 of a carcass grade lower because of conformation (old grading standards). Simmental cross steers had the largest ribeye area (12.95 sq in) and Jersey cross steers the smallest (11.0 sq in). HA steers had the most fat cover (.93 in) and JH steers the least (.67 in).

Carcass composition was determined by detailed separation of the right side from a sample of 159 steers. Actual kidney, heart and pelvic fat was highest for Jersey crosses (5.7 percent) and lowest for Simmental crosses (3.9 percent). SH steers had the highest actual cutability (51.9 percent), whereas the other crossbred groups ranged between 49 and 50 percent. Jersey cross and HA steers had the most carcass fat (26.3 percent) and the least carcass lean minus the short loin (54.6 percent). SH and BH steers had the least carcass fat (22.1 percent) and SH had the most carcass lean minus shortloin (57.4 percent). Percent bone was lowest for HA steers (11.4 percent). Crosses from Hereford dams had more bone than those from Angus dams (12.4 *vs* 11.9 percent). All crossbred steer groups had acceptable tenderness as determined by Warner-Bratzler shear.

In cooperation with USDA, Science and Education Administration, Southern Region.

Introduction

During the past several years there has been a continued increase in the use of crossbreeding to improve productivity of commercial beef herds. This shift to crossbreeding systems has resulted primarily from: 1) research that demonstrates productivity per cow in the herd can be substantially increased through a planned crossbreeding system and 2) economic conditions in the cattle industry that have forced cattlemen to strive for maximum production efficiency. Planned crossbreeding systems can increase herd productivity because of the opportunity to combine desirable characteristics of two or more breeds and by increased performance due to heterosis. Research has indicated that the majority of the increased production efficiency from crossbreeding resulted from increased fertility and maternal ability of the crossbred cow and liveability and early growth of the crossbred calf. Use of crossbred cows accounts for over half of the increased productivity from a crossbreeding system.

Research studies are needed to more clearly evaluate the biological characteristics of breeds available for beef production in the U.S. and how they will complement each other in planned crossbreeding systems to maximize production efficiency under various climatic and management conditions. Even though carcass traits generally exhibit little heterosis, it is important to evaluate carcass traits of crossbred animals to examine how well the breeds complement each other for these economically important traits. The objective of this study was to characterize carcass traits of crossbred steers of differing biological types produced by mating Hereford, Angus, Simmental, Brown Swiss and Jersey bulls to Hereford and Angus cows.

Experimental Procedures

Data analyzed in this study were the carcass measurements on 269 crossbred steers produced by mating Hereford (H), Angus (A), Simmental (S), Brown Swiss (B) and Jersey (J) bulls to Hereford and Angus cows. Thus, there were eight crossbred groups: HA, AH, SA, SH, BA, BH, JA and JH. Reciprocal Hereford x Angus crosses were combined into a single crossbred group for feeding and carcass evaluation and will be referred to as HA in this report.

The steers were born mostly during February-April of 1975 and 1977 at the Lake Carl Blackwell Research Range west of Stillwater. Calves remained with their dams on native range without creep feed until they were weaned in September at an average age of 205 days. All steers were trucked to the Southwestern Livestock and Forage Research Station at El Reno, Oklahoma the same day they were weaned.

Following weaning, one-half of the steers were placed immediately into the feedlot and the other half were allowed to graze wheat pasture and placed in the feedlot as yearlings. During the finishing phase for both management groups, the steers from each crossbred group were separated into two finishing pens. Thus, during the finishing phase for each management group each year the seven crossbred steer groups were separated into 14 finishing pens and self fed a milo and corn based finishing ration. Steers were individually slaughtered as they reached an estimated choice slaughter grade as determined by visual appraisal. Each steer selected to be slaughtered was removed from feed and water 12 hr prior to obtaining the final slaughter weight.

The steers were slaughtered in a commercial packing plant. Carcasses were allowed to cool for 48 hr before obtaining standard carcass data with the assistance of a federal grader. In each of the four slaughter groups (two management systems and two years) six carcasses from each crossbred group were randomly designiated and the right side shipped to the OSU Meat Lab for detailed carcass evaluation.

Results and Discussion

Comparisons between crossbred groups for feedlot performance under the two management systems (placed on feed at weaning *vs* yearling ages) were reported in the 1975 Animal Science Research Report (Okla. Agr. Exp. Sta. Res. Report MP-94:51). Preliminary analysis indicated that differences between crossbred groups did not have any important interactions with either years or management systems. Thus, data have been averaged over years and management systems to make comparisons between crossbred groups relative to slaughter and carcass traits.

Table 1 presents means for slaughter and carcass traits measured on all steers. Brown Swiss cross and SH steers were the oldest at slaughter (518 days) whereas, SA, JH and HA steers were intermediate in slaughter age (averaged 501 days) and JA steers were slaughtered at the youngest age (492 days).

Simmental crosses and Brown Swiss crosses were the heaviest steers at slaughter, averaging 1110 lb, followed by HA steers at 1035 lb and Jersey cross steers at 924 lb. Dressing percents were very similar for HA, Simmental crosses and Brown Swiss crosses and ranged from 60.9 to 61.4 percent. Jersey cross steers had the lowest dressing percent at 59.6 percent.

Carcass weight per day of age, an important trait to consider when selecting for a meat type animal, was significantly heavier for SA steers (1.39 lb/day) than for any other crossbred group. Brown Swiss cross, HA and SH steers had intermediate carcass weights per day of age ranging from 1.28 to 1.32 lb/day. Jersey cross steers gained carcass weight at the rate of 1.12 lb/day.

Since each steer was slaughtered when a choice carcass grade was anticipated, carcass quality grade should have been similar among crossbred groups. However, Jersey crosses failed to grade (by the old grading standards) low choice by 1/6 of a grade. As can be seen in Table 1, this failure to grade was

Table 1. Average performance of each two-breed cross for certain slaughter and carcass traits measured oteers

Crossbred Group[1]	No. Steers	Slaughter Age, days	Slaughter Weight, lb	Dressing Percent	Car. Wt. Per Day of Age (lb/day)	Ribeye Area, in[2]	Avg Fat Thickness, in	Marbling Score[2]	Conformation[3]	ty[3]
HA	61	498^{c,d}	1035^{c}	61.1^{a}	1.29^{b}	12.0^{c}	.93^{a}	4.83^{a}	11.84^{a}	6^{a}
SA	35	504^{b,c}	1129^{a}	61.4^{a}	1.39^{a}	12.9^{a,b}	.80^{b}	4.80^{a}	12.23^{a}	5^{a}
SH	38	518^{a}	1110^{a,b}	60.9^{a}	1.30^{b}	13.0^{a}	.74^{b,c}	4.66^{a}	12.01^{a}	5^{a,b}
BA	43	515^{a,b}	1096^{b}	61.2^{a}	1.30^{b}	12.4^{b,c}	.77^{b}	4.94^{a}	11.32^{b}	5^{a,b}
BH	33	521^{a}	1105^{a,b}	61.3^{a}	1.32^{b}	12.8^{a,b}	.79^{b}	5.31^{a}	11.12^{b}	4^{a}
JA	35	492^{d}	938^{d}	59.5^{b}	1.15^{c}	10.9^{d}	.77^{b,c}	5.05^{a}	8.94^{c}	8^{b}
JH	27	503^{b,c}	910^{d}	59.7^{b}	1.10^{c}	11.0^{d}	.67^{c}	4.89^{a}	9.00^{c}	4^{b}

^{a,b,c,d}Means in the same column that do not share at least one superscript differ significantly at the .05 probability level.

[1]A=Angus, H=Hereford, S=Simmental, B=Brown Swiss, J=Jersey.

[2]Marbling score equivalents: Modest=6, Small=5, Slight=4.

[3]Conformation and Quality Grade equivalents: Prime=13, Choice+=12, Choice=11, Choice−=10, Good+=9, Good=8, Good−=7.

Table 2. Carcass composition and tenderness evaluation for each two-breed cross

Crossbred[1] Group	No. Steers	Actual KPH Fat, %	Actual Cutability, %	Carcass Composition, % Fat	Lean[2]	Trimmed Shortloin[3]	Bone
HA	25	3.87^{c}	49.0^{d}	26.3^{a}	54.6^{c}	5.8^{a}	11.4^{d}
SA	21	4.10^{b,c}	50.0^{b,c,d}	23.8^{b,c}	55.8^{b,c}	5.9^{a}	11.8^{c,d}
SH	24	3.69^{c}	51.9^{a}	21.9^{d}	57.4^{a}	6.1^{a}	12.4^{a,b}
BA	23	4.45^{b}	50.2^{b,c}	24.2^{b}	55.7^{b,c}	5.8^{a}	11.9^{c}
BH	23	4.16^{b,c}	50.8^{a,b}	22.3^{c,d}	56.0^{b}	5.9^{a}	12.4^{a,b}
JA	22	5.84^{a}	49.4^{c,d}	25.3^{a,b}	54.7^{b,c}	5.9^{a}	12.0^{b,c}
JH	21	5.62^{a}	49.4^{c,d}	25.0^{a,b}	54.5^{c}	5.9^{a}	12.5^{a}

^{a,b,c,d}Means in the same column that do not share at least one superscript differ significantly at the .05 level.

[1]A=Angus, H=Hereford, S=Simmental, B=Brown Swiss, J=Jersey.

[2]Does not include the lean from the closely trimmed shortloin.

[3]Includes a small amount of fat and bone left on the closely trimmed shortloin.

due to conformation and not by an inability to marble. Marbling did not differ significantly among crossbred groups, whereas, conformation was significantly lower for Jersey crosses than for any other crossbred group.

Simmental cross steers had the largest ribeye area (12.95 sq in), followed by Brown Swiss cross steers (12.6 sq in), HA steers at 12.0 sq in and Jersey cross steers at 10.95 sq in. HA steers had the most fat cover (.93 in) and JH had the least (.67) while the other crossbred groups were similar and ranged from .74 to .80 in.

Table 2 presents carcass composition and tenderness traits that were obtained from detailed carcass evaluations conducted on a sample of steers from each crossbred group. Jersey cross steers had significantly more actual kidney, heart and pelvic fat (5.73 percent) than any other crossbred group, whereas, BA had 4.45 percent and the other crosses ranged from 3.69 to 4.10 percent. SH steers had the highest actual cutability (51.9 percent), whereas, the other crossbred groups were similar and ranged from 49.0 to 50.0 percent.

Jersey cross and HA steers had the highest percent carcass fat (25.5 percent), followed by BA and SA (24.0 percent), and SH and BH had the least carcass fat (22.1 percent). Trimmed shortloin did not significantly differ among crossbred groups. Percent carcass lean (minus the lean in the shortloin) was highest for SH steers (57.4 percent) followed by Brown Swiss cross and SA steers (55.8 percent). Jersey cross and HA steers had the least carcass lean (54.6 percent).

Percent bone was lowest for HA steers (11.4 percent) and the other sire breed group were similar and averaged 12.1 percent. However, crosses from Angus dams averaged 11.9 percent bone as compared to 12.4 percent bone for crosses from Hereford dams.

Tenderness, as mechanically determined by Warner-Bratzler shear force, ranged from 15.9 lb for Jersey cross steers to 19.3 lb for SH steers, but all were in an acceptable range for consumer acceptability.

Performance to Weaning of Three-Breed Cross Calves Sired by Red Poll And Shorthorn Bulls

C. G. Belcher, R. R. Frahm
L. W. Knori and E. N. Bennett

Story in Brief

Various two-breed cross heifers were mated to Red Poll and Shorthorn bulls to produce their first calf at two years of age. A total of 334 three-breed cross calves were weaned over a three-year period and performance to weaning were very similar for calves sired by Red Poll and Shorthorn bulls. Some calving assistance was required for 26.1 percent of the calves. Overall, the calves weighed 63.5 lb at birth and 413.5 lb at weaning and had an average conformation grade of low choice. Shorthorn sired calves had slightly higher conformation scores and condition scores at weaning than the Red Poll sired calves.

Introduction

Research has shown that well designed crossbreeding systems can substantially increase percent calf crop weaned and calf weaning weights through hybrid vigor and combining the desirable traits of two or more breeds. An extensive research program is currently underway at the Oklahoma Agricultural Experiment Station to compare lifetime productivity of various two-breed cross cows mated to bulls of a third breed. Primarily, bulls from relatively large breeds will be used to sire calves in this study. However, to avoid excessive calving difficulty, Red Poll and Shorthorn bulls were mated to the crossbred heifers to produce their first calf at two years of age. The purpose of this study was to compare the performance of three-breed cross calves to weaning age that were sired by Red Poll and Shorthorn bulls.

Experimental Procedure

Hereford, Angus, Simmental, Brown Swiss and Jersey bulls were mated to Angus and Hereford cows to produce two-breed cross heifers in the spring of 1973, 1974 and 1975. Red Poll and Shorthorn bulls were mated to these eight different two-breed cross heifer groups (Hereford x Angus, Angus x Hereford, Simmental x Angus, Simmental x Hereford, Brown Swiss x Angus, Brown Swiss x Hereford, Jersey x Angus and Jersey x Hereford) to produce their first calves as two-year olds in the spring of 1975, 1976 and 1977. A total of 341

Table 1. Performance to weaning of three-breed cross calves sired by Shorthorn and Red Poll bulls

Trait	Breed of Sire		Difference
	Shorthorn	Red Poll	Shorthorn-Red Poll
Number of calves	165	169	
Birthweight, lb	63	64	−1
Calving difficulty score[1]	1.8	2.0	−0.2
Percent calving difficulty[2]	25.9	26.3	−0.4
Preweaning ADG, lb/day	1.72	1.69	0.03
205-day weaning weight, lb[3]	415	412	3
Weaning conformation score[4]	13.1	12.6	0.5*
Weaning condition score[5]	5.4	5.0	0.4*

[1]Calving difficulty: 1=no difficulty, 2=little difficulty, 3=moderate difficulty, 4=major difficulty and 5=caesarian.
[2]Percent calving difficulty is the percentage of births receiving a calving difficulty score of 3, 4 or 5.
[3]Weaning weights were adjusted for age of calf only as all cows were two-year olds. Steer and heifer weights were averaged.
[4]Conformation score equivalents: 12=low choice, 13=average choice and 14=high choice.
[5]Condition score equivalents: range from 1=very thin to 5=average to 9=very fat.
*Differences significant at the .05 probability level.

three-breed cross calves were born and 334 weaned over the three year period. Three bulls of each sire breed were used for these matings each year.

The calves were born in January, February and March of each year at the Lake Carl Blackwell Research Range. Each cow was closely observed during calving and a score was assigned by the herdsman to indicate the level of calving difficulty on a scale ranging from 1=no difficulty to 5=caesarian birth or abnormal presentation. Calves remained on native grass with their dams until they were weaned at an average age of 205 days. At weaning, each calf was weighed and given a conformation score and condition score by a panel of a least three persons.

Results and Discussion

Table 1 presents means for various traits to weaning for the three-breed cross calves produced by each sire breed. Even though Red Poll and Shorthorn bulls were used to sire the first calf of these heifers in order to minimize calving problems, some calving difficulty was still experienced. Of the 341 heifers producing a calf, 89 heifers or 26.1 percent had some calving difficulty and required assistance from the herdsmen. Percent calving difficulty is the percentage of births receiving a score of 3, 4 or 5. A score of 2 represents only minor assistance and was usually administered for the convenience of the herdsman rather than actually being necessary. Birthweights were not very heavy and quite similar for the Red Poll and Shorthorn sired calves (64 *vs* 63 lb). Thus, there was essentially no difference in calving difficulty between the two sire breeds (26.3 *vs* 25.9 percent).

Growth performance to weaning was very similar for the calves from both sire breeds and the average 205-day weaning weight was 413.5 lb (unadjusted for age of dam and averaged over sexes). The only statistically significant differences between sire breeds were that the Shorthorn sired calves were .5 of a weaning conformation score and .4 of a condition score higher than the Red Poll sired calves. Thus, the Shorthorn sired calves appeared to have slightly more muscle as well as more fat at weaning.

Overall, the performance of three-breed cross calves sired by Red Poll and Shorthorn bulls were very similar, and the slight differences that were detected may simply reflect differences between particular bulls rather than real breed differences. Feedlot and carcass performance of the three-breed cross calves born in 1975 were reported in the 1977 Animal Science Research Report (Okla. Agr. Exp. Sta. Res. Report MP-101:80) and the performances were similar for both sire breeds.

Productivity of Two-Year Old Crossbred Cows Producing Three-Breed Cross Calves

C. G. Belcher, R. R. Frahm,
L. W. Knori and E. N. Bennett

Story in Brief

Productivity was measured on 434 two-year old heifers of seven crossbred groups (Hereford x Angus, Simmental x Angus, Simmental x Hereford, Brown Swiss x Angus, Brown Swiss x Hereford, Jersey x Angus and Jersey x Hereford) mated to Red Poll and Shorthorn bulls. Percent calf crop weaned varied greatly among crossbred groups from Jersey cross and Brown Swiss x Angus cows averaging 88 percent to Simmental x Hereford cows at 53 percent. The heaviest calves at weaning were produced by Brown Swiss x Angus cows at 446 lb. Hereford x Angus cows weaned calves averaging 369 lb and the other crossbred dam groups were similar at 416 lb. Jersey cross and Brown Swiss x Angus cows were most productive in terms of pounds of calf weaned per cow exposed in the breeding herd by 102 lb (37 percent) above the Hereford x Angus crosses, followed by the Brown Swiss x Hereford and Simmental x Angus groups (30.5 lb or 11 percent above the Hereford x Angus crosses). Simmental x Hereford cows weaned 57 fewer lb of calf per heifer exposed (21

percent) than Hereford x Angus cows. Individual cow efficiency, measured by calf weaning weight divided by cow metabolic size, favored Jersey cross cows by 18.1 percent, Brown Swiss cross cows by 13.1 percent and Simmental cross cows by 5.2 percent over Hereford x Angus crosses.

Introduction

The growing urgency for more efficiency in beef cattle production has focused attention on crossbreeding. Research has demonstrated that crossbreeding systems can greatly increase percent calf crop weaned and calf weaning weights, thus resulting in increased productivity for the cow herd. Many studies have indicated that the pounds of calf weaned per cow exposed in the breeding herd will be increased 20 to 25 percent by a planned crossbreeding system.

Since over half of the increased productivity in a crossbreeding system results from using a crossbred cow, an extensive research program is presently underway at the Oklahoma Agricultural Experiment Station to compare the lifetime productivity of various two-breed cross cows mated to a bull of a third breed. The purpose of this study was to compare the productivity of the various two-breed cross heifer groups when managed to produce their first calf at two years of age.

Experimental Procedures

Angus and Hereford cows were mated to produce crossbred calves in 1973, 1974 and 1975 sired by Angus, Hereford, Simmental, Brown Swiss and Jersey bulls. Hereford x Angus and Angus x Hereford crosses were combined into a single group. Four different bulls of each breed were used each year. All heifer calves produced by these matings were kept in the herd for evaluation as cows. A total of 434 two-breed cross heifers entered the cow herd. A random half of the heifers in each crossbred group were mated to Red Poll bulls and the other half to Shorthorn bulls from April 15 to July 1 to produce their first calf at two years of age in the Spring of 1975, 1976 or 1977. A total of 334 three-breed cross calves were weaned (120 calves in 1975, 124 in 1976 and 90 in 1977). Three bulls from each sire breed were used in these matings each breeding season. Red Poll and Shorthorn bulls were used primarily as an attempt to avoid excessive calving problems associated with two-year old heifers.

All cattle were managed on native and bermuda grass pasture at the Lake Carl Blackwell Research Range. Calves were born in January, February and March of each year and remained with their dams on native grass until they were weaned at an average age of 205 days.

Results and Discussion

Table 1 presents the reproductive performance of the two-year old crossbred cows. Eighty-four percent of all the heifers exposed to breeding calved, ranging from 58 percent for Simmental x Hereford to an average of 94 percent for Jersey x Hereford and Brown Swiss x Angus heifers.

Each calf was observed during birth and given a calving score. Percent calving difficulty is the percentage of births that were categorized as difficult births and required assistance from the herdsman. Based on the scoring system used, births scored 3 or higher were categorized as difficult births. A score of 2 is used for only minor assistance usually administered for the convenience of the herdsman rather than actually being required. The percent of heifers requiring assistance at calving varied from 48 percent for Simmental x Hereford to an average of 30.4 percent for Hereford x Angus, Simmental x Angus and Brown Swiss x Hereford to 20.3 percent for Brown Swiss x Angus and Jersey x Angus to 14.8 percent for Jersey x Hereford heifers. Overall, some assistance was provided for 26.1 percent of the calves and a total of 13 caesarian operations were performed.

Of the 434 heifers placed in the breeding pastures 79 percent produced a live calf, ranging from 91.5 percent for the Jersey x Hereford to 55.6 percent for the Simmental x Hereford. Overall, 77 percent of the 434 heifers exposed to breeding weaned a calf. There was considerable variation among crossbred groups in the percentage that weaned a calf. Jersey cross and Brown Swiss x Angus cows were similar and had the highest percentage weaned (averaged 88.2 percent) which was about 16 percent more than were weaned by Hereford x Angus, Simmental x Angus and Brown Swiss x Hereford cows (averaged 72.3 percent). Simmental x Hereford cows had the poorest reproductive performance and only 53.3 percent weaned calves.

A critical period in the reproductive management of young cows is the breeding season following the birth of the first calf at two years of age. Rebreeding performance of those crossbred heifers that calved is presented in the last column of Table 1. Overall, 73.4 percent of the crossbred cows calving as two-year olds rebred. Rebreeding performance ranged from 88.9 percent for Jersey crosses to 72.9 percent for Hereford x Angus and Simmental x Angus to 61.5 percent for Simmental x Hereford and 46.1 percent for Brown Swiss x Hereford cows.

Performance of the three-breed cross calves to weaning is presented in Table 2. Calves from Jersey cross cows had the lightest birthweights and averaged 59.3 lb which perhaps accounts for some of the easier calving experienced by the Jersey crosses. Calves from Jersey x Hereford cows were similar in birthweight to those from Hereford x Angus at 61.1 lb while the Simmental x Angus and Brown Swiss cross cows had the heaviest calves (averaged 67 lb). Simmental x Hereford cows, which experienced the most calving difficulty, had an average birthweight of 64.7 lb.

Simmental, Brown Swiss and Jersey cross cows were all expected to produce more milk than the Hereford x Angus crosses and thus wean heavier calves. The heaviest calves were produced by Brown Swiss x Angus cows at

Table 1. Reproductive performance of two-year old crossbred cows

Crossbred cow group[1]	No. of heifers exposed	Percent calving[2]	Percent live calves born[2]	Percent calving difficulty[3]	Calving difficulty score[3]	Percent calves weaned[2]	Percent of cows calving rebred
HA	105	86.7	77.1	30.9	1.96^{bcd}	72.4	72.5
SA	69	81.2	72.4	34.0	2.02^{cd}	72.4	73.2
SH	45	57.8	55.6	48.0	2.28^{d}	53.3	61.5
BA	47	93.6	87.2	19.5	1.60^{ab}	85.1	68.2
BH	50	78.0	76.0	26.3	1.93^{ad}	72.0	46.1
JA	59	89.8	88.1	21.2	1.70^{ac}	88.1	84.9
JH	59	94.9	91.5	14.8	1.57^{a}	91.5	92.9
Overall	434	84.0	78.6	26.1	1.86	77.0	73.4

[1]H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey.
[2]Based on the number of cows exposed in the breeding herd.
[3]Based on the number of cows calving. Calving difficulty scores: 1=no difficulty, 2=little difficulty, 3=moderate difficulty, 4=major difficulty and 5=caesarian or abnormal presentation. Percent calving difficulty is the percentage of births that required assistance from the herdsman (scores of 3 and higher).
[a,b,c,d]Means in the same column that do not share at least one superscript are significantly different at the .05 probability level.

Table 2. Performance to weaning of three-breed cross calves produced by two-breed cross cows

Crossbred cow group[1]	No. calves	Birth weight (lb)	Weaning[2] conformation	Weaning[3] condition	Preweaning ADG (lb/day)	205-day weaning weight[4] lb	205-day weaning weight[4] % HA
HA	78	61.5^{b}	12.5^{a}	4.9^{a}	1.50^{a}	369^{a}	100.0
SA	50	68.2^{d}	13.1^{bc}	5.3^{b}	1.73^{b}	423^{c}	114.6
SH	24	64.7^{c}	13.0^{b}	4.9^{ac}	1.68^{b}	406^{b}	110.0
BA	40	66.6^{cd}	13.4^{c}	5.3^{b}	1.85^{c}	446^{d}	120.9
BH	36	66.3^{cd}	13.2^{bc}	5.4^{b}	1.72^{b}	419^{bc}	113.6
JA	52	57.9^{a}	12.5^{a}	5.3^{b}	1.74^{b}	414^{bc}	112.2
JH	54	60.7^{ab}	12.3^{a}	5.2^{bc}	1.74^{b}	417^{bc}	113.0
Total or Overall Avg.	334	63.3	12.8	5.1	1.69	409	

[1]H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey.
[2]Conformation score equivalents: 12=low choice 13=average choice and 14=high choice.
[3]Condition score equivalents: range from 1=very thin to 5=average to 9=very fat.
[4]Weaning weights were adjusted only for the age of calf. Steer and heifer weaning weights were averaged. All dams were two years old at the time of calving.
[a,b,c,d]Means in the same column that do not share at least one superscript are significantly different at the .05 probability level.

446 lb (20.9 percent heavier than from Hereford x Angus). Jersey crosses, Brown Swiss x Hereford and Simmental crosses produced calves averaging 416 lb (12.7 percent heavier than from Hereford x Angus) with Hereford x Angus cows producing the lightest calves at 369 lb. Comparisons of calf preweaning average daily gain was similar to comparisons of calf weaning weight. Calves from Hereford x Angus cows had the slowest preweaning growth rate at 1.50 lb/day and calves from Brown Swiss x Angus cows were the fastest gainers at 1.85 lb/day. Calves from the other crossbred groups were similar in preweaning growth rate and averaged 1.72 lb/day.

Overall, these three-breed cross calves were very uniform in conformation. Calves from Hereford x Angus and Jersey cross cows averaged low choice in conformation while the others were average choice. They were also very uniform in condition with calves from Hereford x Angus and Simmental x Hereford cows slightly below average with a condition score of 4.9 and the other groups above average with a condition score of 5.3.

In Table 3, comparisons among crossbred groups in total productivity for the breeding herd were made by combining the percentage of cows exposed that weaned calves with the respective weaning weights to obtain the pounds of calf weaned per cow exposed in the breeding herd. Simmental x Hereford cows were 57 lb (20.8 percent) lower in productivity than Hereford x Angus. Jersey cross and Brown Swiss x Angus cows were 102 lb (37.1 percent) more productive than Hereford x Angus cows and Simmental x Angus and Brown Swiss x Hereford cows were 31 lb (11 percent) more productive.

Larger cows require more feed during the year for body maintenance and thus need to produce larger calves in order to be competitive with small cows in efficiency of production. Cow efficiency data are presented in Table 4. The heaviest cows were Simmental x Angus at 801 lb (12 percent heavier than the Hereford x Angus). Brown Swiss cross and Simmental x Hereford cows averaged 26 lb (4 percent) heavier than Hereford x Angus cows and Jersey crosses were 55 lb (8 percent) lighter. One measure of cow efficiency is the ratio of calf weaning weight to cow weight. Larger values are indicative of more efficient cows. On this basis, Jersey cross cows were most efficient, weaning

Table 3. Weaning weight production per crossbred cow in the breeding herd

Crossbred cow group[1]	Pounds of calf weaned per cow exposed	
	lb	%HA
HA	274	100.0
SA	307	112.0
SH	217	79.2
BA	380	138.7
BH	302	110.2
JA	365	133.2
JH	382	139.4

[1]H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey

Table 4. Average crossbred cow weights and measures of cow efficiency

Crossbred	No. of	Average cow weight[2]		Calf Wn. Wt. ÷ Cow Wt.		Calf Wn. Wt. ÷ Cow Metabolic Wt.	
cow group[1]	cows	lb	%HA	Ratio	%HA	Ratio	%HA
HA	105	716	100.0	.527[a]	100.0	2.71[a]	100.0
SA	69	801	111.9	.537[a]	101.9	2.84[b]	104.8
SH	45	746	104.2	.549[a]	104.2	2.86[b]	105.5
BA	47	750	104.7	.600[b]	113.9	3.12[cd]	115.1
BH	50	729	101.8	.582[b]	110.4	3.01[c]	111.1
JA	59	661	92.2	.638[c]	121.1	3.22[d]	118.8
JH	59	662	92.4	.627[c]	119.0	3.18[d]	117.3

[1]H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey.

[2]Average of spring weight after calving and prior to breeding and the fall weight after weaning.

[a,b,c,d]Means in the same column that do not share at least one superscript are significantly different at the .05 probability level.

calves at 63 percent of their body weight which was 20 percent more efficient than Hereford x Angus crosses. Brown Swiss crosses were 12 percent more efficient than Hereford x Angus cows and Simmental crosses were only slightly more efficient (3.5 percent) than Hereford x Angus cows.

Nutritional requirements to maintain a cow of a particular size is dependent upon the metabolic body size of the animal which can be estimated as the animal's weight taken to the 0.75 power. Since differences in feed requirements between crossbred groups should be estimated with greater precision when based on metabolic cow size, the ratio of calf weight to cow metabolic weight was also considered. On this basis, as compared to Hereford x Angus cows, Jersey cross and Brown Swiss x Angus cows were 17.1 percent more efficient, Brown Swiss x Hereford were 11.1 percent more efficient and Simmental crosses were 5.2 percent more efficient.

These data suggest some relatively large differences in two-year old cow productivity among the various crossbred groups. Some of these may be, at least in part, due to differences in rate of physiological development and maturity. Thus, the relative comparisons in productivity and production efficiency may change as the cows mature.

A Comparison of Profitability of Two-Year-Old Crossbred Cows

R. L. Hintz and R. R. Frahm

Story in Brief

Profitability of raising a calf of various two-year-old two-breed cross cows was compared. Data on two-year-old two-breed cross cows that have been described in the preceeding paper in this report and information from other sources were used to simulate the production systems of these two-breed cross cows.

Dry matter requirements or nutritional requirements for each type of cow were determined from recommended requirements based on milk production, weight, stage of pregnancy, and stage of lactation of the cow. An average of the market prices of beef for the last five years and current costs of feed were used to provide an economical comparison of systems using two-breed cross cows.

Beef production systems based on different two-breed cross cows were compared using a variety of criteria. Considering only the feedlot stage of the production system, crossbreeding systems using Simmental-Angus cross cows provided calves that showed the highest dollar return per calf in the feedlot with a return of $.40 to $15 advantage over the return from other crossbred cow groups. Looking at dollar return per cow, crossbreeding systems using Jersey-Hereford cross cows showed the highest return with a $2 to $57/cow return higher than that of other crossbred cow groups. Crossbreeding systems with Jersey-Hereford cross cows showed the highest return on each dollar invested with a $.03 to $.46 higher return per dollar invested than that of other crossbred cow groups.

Introduction

Beef cattle producers are interested in ways to improve profit. An extensive research program is presently under way at the Oklahoma Agricultural Experiment Station to compare the lifetime productivity of various two-breed cross cows mated to a bull of a third breed. The use of crossbred cows presents a genetic means for improving production, and it is important to look at differences between various kinds of crossbred cows from an economical standpoint, in order to determine which crossbred cows provide the most profit. The purpose of this study was to compare the profitability of various two-year-old two-breed cross cows under alternative production systems.

Experiment Procedures

Productivity data on the various two-breed cross cows mated to Shorthorn or Red Poll bulls are presented in the preceeding paper and information on the two-breed cross cows used in this study is presented in Table 1. The amount of feed to maintain a cow for a year was estimated based on the weight, stage of pregnancy, milk production during lactation and the stage of lactation utilizing procedures developed by previous research. The amount of feed used in the feedlot can be determined from the data collected on the calves of the two-breed cross cows.

Additional parameters assumed for all systems were:

1. Annual fixed cost per cow of $55, includes labor and non-nutritional costs such as taxes, fees, interest, veterinary expenses and repair on facilities.
2. Sale prices of $37.13/cwt for slaughter grade choice animals, $40.42/cwt for weaned calves. These are average sale prices for heifers and steers for the last five years.
3. Cost of native pasture to maintain the cow herd was $24/ton of dry matter.
4. Cost per day in the feedlot of $5.00 for overhead costs.

Table 1. Data on two-year-old two-breed cross cows

Trait	Crossbred cow groups[1]						
	HxA	SxA	SxH	BxA	BxH	JxA	JxH
Weight of cow	731.5	817	766	782	756	678	687
Average daily milk production (lb)	9.58	14.53	12.35	16.55	16.38	15.27	14.49
Percent pregnant	86.7	81.2	57.8	93.6	78.0	89.8	94.9
Percent live calves	77.1	72.4	55.6	87.2	76.0	88.1	91.5
Percent weaned calves	72.4	72.4	53.3	85.1	72.0	88.1	91.5
Weaning weight of calf[2](lb)	369	423	406	446	419	414	417
Slaughter weight of calf (lb)[2]	812	891	884	900	897	819	828
Days in feedlot for calf[2]	139	135	139	141	141	129	129
Feed efficiency (lb feed/lb gain)[2]	7.66	7.53	7.41	8.12	7.49	8.28	8.11
Gain in feedlot (lb)[2]	365	377	390	377	393	306	321

[1]A=Angus, H=Hereford, S=Simmental, B=Brown Swiss and J=Jersey
[2]Average of steer and heifer calves

5. Cost of the ration fed in the feedlot was $4.31/cwt.
6. Each system started with a 100 cows.

Profitability of the different crossbred cow groups was compared under four alternative management schemes:

1. All 100 cows are kept the full year from weaning to weaning (MS1).
2. Only the pregnant cows are kept for the full year. The number of cows kept for each two-breed cross was estimated as the pregnant percentage times 100. Culling based on pregnancy examination occurs following the breeding season (MS2).
3. All cows are kept until calving time. After calving, only the cows that had a live calf are kept for the rest of the year (MS3).
4. Only pregnant cows are kept following breeding season and after calving only those cows that had a live calf are kept the remainder of the year (MS4).

Using these parameters, expenses and income of the various production systems were simulated. Production systems using different management schemes and two-breed cross cows were compared in terms of total saleable product of slaughter weight calves or weaning weight calves, dollar return per calf in feedlot, dollar return per cow, or dollar return per dollar invested.

Results and Discussion

Before comparing the various production systems, it should be pointed out that a complete cost of maintaining a cow herd was not estimated. The costs ignored include cost of the pasture consumed by the calves before weaning and capital investment of maintaining the pasture. The gain in weight by open cows during the pregnancy period and non-lactating cows during the lactation period was not evaluated. Therefore, the absolute estimate of profit for any production system is inflated. However, differences in profitability of two-breed cross cows within management schemes should not be affected by the costs ignored.

Comparison of two-breed cross cows

Cost of feed and price of saleable product are listed in Table 2 and fixed costs are listed in Table 3. Crossbreeding systems using Brown Swiss-Angus, Jersey-Hereford, or Jersey-Angus cross cows had a higher amount of total saleable product with an additional gross return of $2,724 to $10,923 above the gross return from other crossbred cow groups. Looking at total saleable product of weaned calves, crossbreeding systems with Jersey-Hereford, Brown Swiss-Angus, or Jersey-Angus cross cows provided higher additional gross return of $2,364 to $6,675 above gross return from other crossbred cow groups.

Using data in Tables 2 and 3, the dollar return per cow can be calculated by subtracting the estimated cost of producing a saleable product from the gross return of the saleable product and dividing the difference by 100. A negative return per cow indicates a loss per cow. Keep in mind that the estimate of return per cow is inflated because all of the cost has not been considered. However, the costs that have not been included are expected to be very similar for all crossbred cow groups. Consequently differences in return per cow should provide a valid estimate of the differences in profitability between different two-breed cross cows under alternative management schemes. Dollar return per cow is listed in Table 4.

When selling weaned calves, crossbreeding systems using Jersey-Hereford, Jersey-Angus, or Brown Swiss-Angus cross cows had a $8 to $50 return per cow advantage over the return per cow from other crossbred cow groups. Whereas, crossbreeding systems using Hereford-Angus or Simmental-Hereford cross cows had a $.21 to $39 return per cow lower than the return per cow from other crossbred cow groups.

Considering feedlot performance, calves of Simmental-Angus, Simmental-Hereford, or Brown Swiss-Hereford cross cows had a $5 to $13 return per calf advantage over the return per calf of other two-breed cross cows. Whereas, calves of Brown Swiss-Angus cross cows had a $6 to $15 return per calf lower than the return per calf of other two-breed cross cows.

When selling slaughter calves, crossbreeding systems using Jersey-Hereford or Jersey-Angus cross cows had a $7 to $55 return per cow advantage over the return per cow from other crossbred cow groups. Whereas, crossbreeding systems using Hereford-Angus or Simmental-Hereford cross cows had a $6 to $41 return per cow lower than the return per cow from other crossbred cow groups.

Table 2. Cost of feed and prices of saleable product in dollars

Trait	Crossbred cow groups[1]						
	HxA	SxA	SxH	BxA	BxH	JxA	JxH
Cost of feed used for cows							
MS1[2]	7001	8073	6932	8481	7823	7746	7763
MS2	6307	6978	4655	8130	6647	7244	7510
MS3	6331	7167	5589	8087	7104	7417	7526
MS4	5889	6699	4519	7868	6368	7197	7415
Cost of feed used in feedlot	8796	8858	6656	11228	9134	9589	10267
Sale price of weaned calves	10798	12379	8747	15341	12194	14743	15422
Sale prices of slaughter calves	21828	23952	17514	28438	24034	26758	28130

[1]A=Angus, H=Hereford, S=Simmental, B=Brown Swiss and J=Jersey
[2]MS1-MS4 - management schemes 1-4

Table 3. Fixed costs per herd in dollars

Trait	Crossbred cow groups[1]						
	HxA	SxA	SxH	BxA	BxH	JxA	JxH
Annual fixed cost							
MS1[2]	5500	5500	5500	5500	5500	5500	5500
MS2	4769	4466	3179	5148	4290	4939	5220
MS3	4791	4645	4125	5104	4757	5131	5237
MS4	4471	4193	3111	4950	4228	4886	5114
Fixed cost for feedlot	695	675	695	705	705	645	645

[1]A=Angus, H=Hereford, S=Simmental, B=Brown Swiss and J=Jersey
[2]MS1-MS4 - management schemes 1-4

Table 4. Dollar return per animal

Trait	Crossbred cow groups[1]						
	HxA	SxA	SxH	BxA	BxH	JxA	JxH
Calves sold at weaning (dollar return/cow)							
MS1[2]	−17.02	−11.65	−36.85	13.61	−11.29	14.96	21.59
MS2	−2.77	9.34	9.13	20.64	12.57	25.60	26.93
MS3	−3.23	5.67	−9.66	21.51	3.34	21.94	26.59
MS4	4.38	14.86	11.17	25.23	14.98	26.59	28.93
Calves sold at slaughter (dollar return/cow)							
MS1	−1.64	8.75	−22.69	25.24	8.71	32.78	39.55
MS2	12.61	29.74	23.30	32.27	32.57	43.41	44.90
MS3	12.15	26.07	4.50	33.14	23.34	39.75	44.56
MS4	19.77	35.36	25.34	36.87	34.98	44.41	46.90
Feedlot performance (dollar return/calf)	21.25	28.18	26.58	13.68	27.78	20.22	19.63

[1]A=Angus, H=Hereford, S=Simmental, B=Brown Swiss and J=Jersey
[2]MS1-MS4 - management schemes 1-4

Table 5. Dollar return per dollar invested

Trait	Crossbred cow groups[1]						
	HxA	SxA	SxH	BxA	BxH	JxA	JxH
Calves sold at weaning							
MS1[2]	.86	.91	.70	1.10	.92	1.11	1.16
MS2	.97	1.08	1.12	1.16	1.11	1.21	1.21
MS3	.97	1.05	.90	1.16	1.03	1.17	1.21
MS4	1.04	1.14	1.15	1.20	1.14	1.22	1.23
Calves sold at slaughter							
MS1	.99	1.04	.89	1.10	1.04	1.14	1.16
MS2	1.06	1.14	1.15	1.13	1.16	1.19	1.19
MS3	1.06	1.12	1.03	1.13	1.11	1.17	1.19
MS4	1.10	1.17	1.17	1.15	1.17	1.20	1.20
Feedlot performance	1.16	1.21	1.19	1.10	1.20	1.17	1.16

[1]A=Angus, H=Hereford, S=Simmental, B=Brown Swiss and J=Jersey
[2]MS1-MS4 - management schemes 1-4

Dollar return per dollar invested for various production systems using two-breed cross cows are listed in Table 5. Dollar return per dollar invested was calculated by dividing the cost of producing a saleable product into the gross return from the saleable product. A ratio less than 1.00 indicates a loss per dollar invested. When selling at slaughter weight, crossbreeding systems using Jersey-Angus or Jersey-Hereford cows had a $.03 to $.27 higher return per dollar invested than the return from other crossbred cow groups. When selling at weaning, crossbreeding systems using Jersey-Angus, Jersey-Hereford, or Brown Swiss-Angus cross cows provided a $.05 to $46 higher return per dollar invested than the return from other crossbred cow groups. For feedlot performance, calves of Simmental-Angus, Simmental-Hereford or Brown Swiss-Hereford cross cows provided a $.03 to $.10 higher return per calf than the return from calves of other two-breed cross cows. However, the differences in dollar return per dollar invested between the crossbreeding systems were not as dramatic as the differences in dollar return per cow. The advantage or disadvantage of crossbreeding systems using Simmental-Hereford cows when compared to other crossbred cow groups varies across management schemes because of the poor reproductive performance of Simmental-Hereford cross cows.

This study has not completely analyzed the profitability of two-year-old two-breed cross cows. Furthermore, differences in profitability may change when the cows are maintained in the herd for several years. However, this study has attempted to indicate which of these two-year-old two-breed cross cows should provide the most profit.

A Preliminary Comparison of the Productivity of Females of Duroc, Yorkshire, Landrace and Spot Breeding

R. K. Johnson, S. D. Welty, R. Vencl and J. Schooley

Story in Brief

Purebred Duroc, Yorkshire, Landrace and Spot females were compared for average litter size and pig weight at birth and at weaning (42 days). The number of dams per breed ranged from 56 to 62. Sows and gilts of each breed were bred to boars of each breed to produce both purebred (64) and crossbred (169) litters.

Litter size at birth was greater for litters from Duroc and Yorkshire dams than for litters from Landrace and Spot dams. However, survival rate to 42 days was 80 percent for pigs by Landrace dams compared to 62 percent, 72 percent and 76 percent for pigs from Duroc, Yorkshire and Spot dams, respectively. Thus by 42 days, Yorkshire and Landrace dams had litters with about one more pig than Duroc and Spot dams. Pigs from Yorkshire dams were lighter at birth and weaning than pigs by dams of the other breeds. Overall, purebred litters were somewhat larger at birth than crossbred litters, but survival rate to weaning was 8.7 percent higher for crossbred pigs than purebred pigs.

Introduction

Crossbreeding capitalizes on genetic differences between breeds and on heterosis; and crossbred systems have been shown to be more efficient in the conversion of feed to pork than purebred systems. Previous Oklahoma Agricultural Experiment Station research with the Duroc, Hampshire and Yorkshire breeds has demonstrated that specific crosses of crossbred females mated to a boar of a third breed result in about 30 percent more litter weight weaned per female exposed than the average of the purebreds. In addition, crossbred pigs grew faster and more efficiently than purebreds.

Several breeds of swine have not been adequately evaluated under controlled experimental conditions so that producers can make decisions as to how they fit in a breeding program. In addition, mating systems involving purebred and crossbred boars have not been compared. In 1976, a project was initiated to evaluate the performance of the Duroc, Yorkshire, Landrace and Spot breeds as purebreds and in two-, three- and four-breed crosses. The present report includes three-seasons of reproductive performance of purebred sows of the four breeds when producing either purebred or two-breed cross litters. Three additional seasons with this mating structure will be completed to more thoroughly evaluate the breeds.

Experimental Procedure

In spring 1976, 25 gilts and four boars of each of the Landrace and Spot breeds were purchased from breeders to establish herds at the Stillwater Experimental Swine Farm. Landrace gilts were purchased from two breeders and were predominantly American Landrace breeding. The Landrace boars (two unrelated Canadian Landrace and two unrelated Swedish Landrace) came from two different sources. Spot boars and gilts were obtained from nine different breeders, two of which provided both gilts and a boar. Duroc and Yorkshire herds, with semi-annual introduction of at least one boar, have been maintained at the farm for several years. Purebreds of each breed will be maintained with semi-annual introduction of boars and within herd selection of gilts.

Purebred boars and females were randomly mated in all combinations to produce purebred and two-breed cross litters that were born during fall 1976, spring 1977 and fall 1977 according to the mating scheme shown in Table 1. Duroc and Yorkshire dams were approximately 30 percent gilts and 70 percent second, third and fourth litter sows and Landrace and Spot females were approximately 40 percent gilts and 60 percent second and third litter sows. No adjustments were made for parity of dam.

Table 1. Number of litters of each mating type for evaluating purebreds and two-breed crosses during each season at the Stillwater Experimental Swine Farm

Breed of sire	Number of sires	Breed of dam			
		D	Y	L	S
Duroc (D)	4	6	4	4	4
Yorkshire (Y)	4	4	6	4	4
Landrace (L)	4	4	4	6	4
Spot (S)	4	4	4	4	6

[a]Litters have been produced during fall 1976, spring 1977 and fall 1977 seasons.

Each season, handmating was used during the eight-week breeding period. Gestating females were maintained in pasture lots and hand-fed a daily ration of four to five pounds of a 15 percent protein corn or milo base diet. Litters were farrowed in confinement, and when the pigs were from one to two weeks old, were moved to pasture lots with three to four litters per lot or to individual pens in an open-front, solid concrete floor building. Litters were provided access to creep feed between two and three weeks and were weaned at six weeks. Individual pig weights were recorded within 12 hours of birth and at weaning.

Results and Discussion

Litter size and average pig weight for purebred and crossbred litters produced by purebred females of each breed is presented in Table 2.

Table 2. Litter size and average pig weight per litter for litters by purebred females when producing purebred and crossbred litters

Mating type	No. of litters	Litter size		Average pig weight per litter, lbs.	
		birth[a]	42 days	birth[a]	42 days
Duroc females[b]	59	11.4	7.1	3.14	25.2
w/purebred	18	11.5	6.0	3.13	25.4
w/crossbred	41	11.3	7.6	3.15	25.1
Yorkshire females[b]	56	11.3	8.1	2.69	23.3
w/purebred	14	12.6	8.2	2.49	22.5
w/crossbred	42	10.9	8.0	2.75	23.5
Landrace females[c]	62	10.0	8.0	3.19	25.8
w/purebred	18	10.6	8.2	2.98	24.8
w/crossbred	44	9.8	7.9	3.28	26.2
Spot females[c]	56	9.4	7.1	3.08	24.3
w/purebred	14	9.4	6.6	3.09	23.8
w/crossbred	42	9.4	7.3	3.07	24.4
Standard deviation		3.0	2.60	.62	5.0

[a]Includes number of fully formed pigs.
[b]Approximately 30% gilts and 70% 2nd, 3rd and 4th litter sows.
[c]Approximately 40% gilts and 60% 2nd and 3rd litter sows.

Although not significant, purebred litters were somewhat larger at birth (.6 pigs/litter) than crossbred litters. However, by 42 days of age, crossbred litters averaged 7.7 pigs per litter compared to 7.3 for purebred litters. The survival rate of crossbred pigs was 8.7 percent higher than for purebred pigs.

Duroc and Yorkshire females had significantly larger litters at birth than Landrace and Spot females, however, Landrace and Yorkshire females weaned litters with about one more pig than Duroc and Spot females. Eighty percent of the pigs raised by Landrace dams survived to weaning compared to 62 percent for Duroc, 72 percent for Yorkshire and 76 percent for Spot. In addition, pigs from Landrace dams were heaviest at birth and weaning while Yorkshire dams had pigs that were the lightest at both ages.

Three additional seasons of this same mating structure will provide additional data to more accurately evaluate these breeds. In addition, crossbred females from these litters are being mated to purebred and crossbred boars to compare the productivity of various crossbred females. These results, in conjunction with growth and carcass merit of the breeds will provide information to make better decisions on how to utilize these breeds in crossbreeding systems.

Growth and Carcass Traits for Pigs Of Four Swine Breeds and Their Crosses

E. R. Wilson, R. K. Johnson, L. E. Walters, S. D. Welty and J. Schooley

Story in Brief

Growth and carcass characteristics of 162 purebred and crossbred boars, 464 purebred and crossbred gilts and 150 purebred and crossbred barrows of Duroc, Yorkshire, Landrace and Spot breeding were compared. Crossbred boars, gilts and barrows grew 11 percent, 7 percent and 9 percent faster, respectively, than purebreds. There were very small differences between purebred and crossbred pigs for backfat probe.

The differences between pigs by Duroc, Yorkshire, Landrace and Spot sires were small for average daily gain and days to 220 lb for boars and barrows and for days to 200 lb for gilts. Duroc sired pigs consistently had less probe backfat than pigs by the other sire breeds. However, pigs from Yorkshire and Spot dams were less fat than those out of Duroc and Landrace dams. Duroc and Spot dams tended to have pigs that gained faster than pigs from Yorkshire and Landrace dams. Gilts were fed either in confinement pens or pasture lots. Gilts raised in confinement were 3.49 days younger at 200 lb and had .03 inch less backfat probe than those raised on pasture. Duroc sires produced barrows which had less carcass backfat, larger loin-eye areas, greater percent lean of carcass weight and higher marbling and firmness scores than sires of the other breeds. Yorkshire, Landrace and Spot sires produced barrows that were very similar for percent lean of carcass weight. Barrows by Yorkshire and Spot dams had less backfat than barrows by Duroc and Landrace dams and Yorkshire dams produced pigs which had the greatest percent lean of carcass weight.

Introduction

This report gives a preliminary analysis of the feedlot performance and carcass merit of Duroc, Yorkshire and Spot breeds of swine and their two-breed crosses. Previous research at this station has shown that crossbred pigs grow faster and more efficiently than purebreds but that there is little difference between them for carcass traits. Previous research has also shown there to be considerable variation among breeds for growth rate, feed efficiency and carcass merit; therefore, the average performance of a breed will be useful in decisions involving breeding programs for commercial production.

There is little data available on the characteristics of the Landrace and Spot breeds for economically important traits. A comparison of these breeds to the Yorkshire and Duroc breeds, for which the performance has been quite well established, will provide useful information to producers for establishing breeding programs to make maximum use of breed differences. This report includes two seasons of performance data. Additional seasons with the same mating structure will be completed to more thoroughly evaluate the breeds.

Materials and Methods

The records of 162 purebred and crossbred boars, 464 purebred and crossbred gilts and 150 purebred and crossbred barrows which were fed during fall 1976 and spring 1977 at the Stillwater Experimental Swine Farm are summarized. Information on the formation of the herds, the mating structure and the handling of sows and litters is presented in the preceeding paper. Seventy-five to 80 litters were produced each season.

The pigs were weaned at six weeks of age at which time the two boars with the heaviest weaning weights were selected from each of 40 litters and the rest of the boars were castrated. Litters from which boars came were randomly selected within breed groups so that there were eight boars from each breed group (4 purebred and 6 reciprocal cross groups).

At approximately eight weeks of age the pigs were allotted to test pens. All boars were fed in confinement with 10 boars per pen. Gilts were randomly allotted within litter to either confinement (10 gilts/pen) or pasture lots. One barrow was randomly selected from each litter and fed on pasture with the gilts. There was approximately 50 pigs per lot.

Boars and barrows were weighed off test at 220 lb and all records were adjusted to 220 lb. Gilts were weighed off test at 200 lb and all records were adjusted to 200 lb. After the barrows were weighed off test, they were slaughtered at the University Meat Laboratory. All carcass measurements were taken after the carcasses had been chilled for at least 24 hr. Standard carcass measurements of length, backfat thickness, loin-eye area and pounds of closely trimmed lean cuts were collected. One loin chop from each carcass was scored for marbling firmness and color.

Results and Discussion

Table 1 contains the overall comparisons between purebreds and crossbreeds and the standard deviation for each trait. Crossbred boars, bar-

Table 1. Comparison of purebred and crossbred boars, barrows and gilts for growth rate, probe backfat thickness and carcass merit

Item	Crossbreds		Purebreds		
	No.	Avg.	No.	Avg.	SD
Boars	94		68		
ADG, lb/day*		1.67		1.51	.21
Age at 220 lb*		167.6		182.8	19.1
Probe backfat at 220 lb		.98		1.00	.13
Barrows	117		33		
ADG, lb/day*		1.64		1.51	
Age at 220 lb*		171.1		182.5	15.8
Probe backfat at 220 lb		1.29		1.23	.15
Carcass length, in*		31.3		31.7	.69
Carcass backfat, in		1.28		1.26	.18
Loin-eye area, in²		4.62		4.56	.53
Percent lean cuts in carcass		56.5		57.0	2.57
Marbling[a] score		3.7		4.0	1.28
Firmness[a] score		4.5		4.8	1.24
Color[a] score*		5.2		5.7	.86
Gilts	340		124		
ADG, lb/day*		1.54		1.44	.17
Age at 200 lb*		166.5		176.0	14.7
Probe backfat, in		1.03		1.02	.12

[a]Score of 1=devoid of marbling, very soft and pale; 5=average marbling and firmness and pink color; 7=abundant marbling, very firm and very dark.

*Significant difference ($P<.05$) between crossbreds and purebreds.

rows and gilts grew 11, 7 and 9 percent faster, respectively, than purebreds. There was essentially no difference between crossbreds and purebreeds for probe backfat thickness or carcass merit; purebred barrows, however, had carcasses that were .4 inches longer than crossbred barrows.

Tables 2 and 3 show the average performance of boars and barrows by each breed of sire and breed of dam, respectively. There is little difference between sire breeds for average daily gain or days to 220 lb; but Landrace and Spot sired boars tended to be slightly younger at 220 lb. Landrace sired boars probed significantly fatter (1.07 in) than did Duroc (.95 in), Yorkshire (.97 in) or Spot (.96 in) sired boars. There were small differences between breeds of dam for average daily gain and days to 220 lb (Table 3). Boars from Yorkshire dams probed significantly less backfat (.92 in) than those from Duroc (1.02 in) or Landrace (1.03 in) dams. Boars from Spot dams were intermediate for probe backfat.

Spot-sired barrows had an average daily gain of 1.65 lb/day and took 168.1 days to reach 220 lb (Table 2). Duroc, Yorkshire and Landrace sired barrows had an average age of 175.4, 174.8, and 177.4 days, respectively, at 220 lb. Duroc sired barrows had the least backfat probe (1.23 in) while Yorkshire sired barrows had the largest backfat probe (1.32 in). Barrows which had Duroc or Spot dams grew fastest and were about eight days younger

Table 2. Average growth rate and probe backfat for boars and barrows by each breed of sire

Breed	Boars				Barrows			
	No.	Avg. daily gain, lb/day	Age at 220 lb	Backfat probe, in.*	No.	Avg. daily gain, lb/day	Age at 220 lb	Backfat probe, in.
Duroc	40	1.59	175.9	.95	38	1.61	175.4	1.23
Yorkshire	41	1.61	174.3	.97	36	1.61	174.8	1.32
Landrace	40	1.61	172.9	1.07	38	1.55	177.4	1.27
Spot	41	1.59	172.7	.96	38	1.65	168.1	1.28

*Breed of sire is significant $P<.01$.

Table 3. Average growth rate and probe backfat for boars and barrows from each breed of dam

Breed	Boars				Barrows			
	No.	Avg. daily gain, lb/day	Age at 220 lb	Backfat probe, in.*	No.	Avg. daily gain, lb/day*	Age at 220 lb*	Backfat probe, in.*
Duroc	41	1.59	172.0	1.02	38	1.67	169.3	1.32
Yorkshire	40	1.58	176.2	.92	34	1.57	179.5	1.23
Landrace	40	1.59	174.5	1.03	45	1.54	177.4	1.31
Spot	41	1.63	173.1	.98	33	1.66	168.7	1.21

*Breed of dam significant $P<.05$.

Table 4. Average growth rate and probe backfat for gilts by each breed of sire

Breed	No.	Avg. daily gain, lb/day	Age at 200 lb.	Backfat probe, in.*
Duroc	117	1.51	170.1	.96
Yorkshire	113	1.51	168.4	1.03
Landrace	111	1.49	170.3	1.07
Spot	123	1.52	167.8	1.08

*Breed of sire significant (P<.01).

Table 5. Average growth rate and probe backfat for gilts by each breed of dam

Breed	No.	Average daily gain, lb/day	Age at 200 lb	Backfat probe, in.*
Duroc	122	1.52	166.5	1.06
Yorkshire	114	1.51	170.1	.98
Landrace	124	1.48	171.2	1.07
Spot	104	1.52	168.7	1.01

*Breed of dam significant (P<.01).

at 220 lb than those with Yorkshire or Landrace dams (Table 3). Yorkshire and Spot dams produced barrows which probed 1.23 inches and 1.21 inches, respectively, as compared to Duroc (1.32 in) and Landrace (1.31 in) dams (Table 4).

Sire breed means for gilt feedlot performance show that Yorkshire and Spot sired gilts tend to be younger at 200 lb but this is not significant (Table 4). Duroc sired gilts had the least backfat probe at 200 lb (.96 in) while Landrace and Spot sired gilts had the greatest backfat probe (1.07 in and 1.08 in, respectively). Duroc dams produced gilts which were 166.5 days at 200 lb in contrast to Yorkshire and Landrace dams whose gilt offspring were 170.1 and 171.2 days at 200 lb (Table 5). Gilts out of Yorkshire and Spot dams were leaner than gilts with Duroc and Landrace dams.

A comparison between gilts raised on pasture or in confinement is presented in Table 6. Confinement, in this case, is an open front, solid concrete floor building with no supplemental heat. Pasture lots were planted to wheat for winter and sorghum for summer and contained an open-front shed as a sleeping area. The same ration was fed to both groups. Breed groups x management interactions were tested, but were not significant, indicating that the differences between breed groups was about the same for pasture and confinement gilts. Gilts which were fed in confinement grew .04 lb per day faster, were 3.49 days younger at 200 lb and probed .03 inches less backfat than gilts raised on pasture (Table 6).

Differences among means for barrows by each breed of sire were significant for all carcass measurement except color score (Table 7). Landrace sired barrows were the longest (31.60 in) and Spot sired barrows were the shortest (31.18 in). Duroc sired barrows had the least backfat (1.18 in) while Yorkshire and Spot sired barrows had the greatest (1.36 in and 1.32 in, respectively).

Table 6. Average growth rate and probe backfat for gilts raised in confinement or on pasture

Item	No.	Avg. daily gain, lb/day*	Age at 200 lb*	Backfat probe, in.*
Confinement	226	1.53	167.19	1.02
Pasture	238	1.49	170.68	1.05

*Significant difference between confinement and pasture (P<.05).

Table 7. Average carcass merit for barrows by each breed of sire

Breed	No.	Length, in.*	Avg. Backfat in.*	Loin-eye area sq. in.*	Percent lean cuts of carcass weight*	Marbling score[a]	Firmness score*[a]	Color score[a]
Duroc	38	31.43	1.18	4.98	59.06	4.45	5.08	5.24
Yorkshire	34	31.37	1.36	4.44	55.91	3.28	4.19	5.31
Landrace	45	31.60	1.24	4.49	55.84	3.24	4.18	5.16
Spot	33	31.18	1.32	4.53	55.44	4.08	4.63	5.47

[a]Score 1 is devoid of marbling, pale and very soft; score of 7 is abundant in marbling, dark and very firm.
*Sire breed is significant P<.05.

Table 8. Average carcass merit for barrows by each breed of dam

Breed	No.	Length, in.	Avg. Backfat in.*	Loin-eye area sq. in.	Percent lean cuts of carcass weight*	Marbling score[a]	Firmness score[a]	Color score[a]
Duroc	38	31.34	1.30	4.56	55.88	4.13	4.95	5.37
Yorkshire	34	31.38	1.21	4.71	57.69	3.59	4.44	5.29
Landrace	45	31.44	1.33	4.55	56.45	3.49	4.18	5.29
Spot	33	31.42	1.23	4.65	56.38	3.91	4.61	5.21

[a]Score of 1 is devoid of marbling, pale and very soft; score of 7 is abundant marbling, dark and very firm.
*Dam breed is significant P<.05.

Duroc sired barrows had the largest loin-eye area (4.98 sq. in) and approximately three percent more lean cuts than barrows by the other three breeds. Duroc sired barrows also had the highest marbling and firmness scores.

Dam breed differences for carcass traits were quite small (Table 8). Barrows from Yorkshire or Spot dams had considerably less backfat than barrows from the other dam breeds. Yorkshire dams produced barrows which had the highest percent lean cuts of carcass weight (57.69 percent) while Duroc dams produced those with the lowest percent (55.88 percent).

These data suggest that there are some differences among the breeds for some of the economically important traits. However, these results should be viewed as preliminary in that only two seasons data have been collected. Also, only five sires and about 30 dams per breed are represented. Four additional seasons utilizing the same mating structure, but with new samples of sires and dams, will provide additional data that will give more precise estimates of the breed differences.

Age and Weight at Puberty for Purebred and Crossbred Gilts of Four Breeds

L. K. Hutchens, R. K. Johnson, S. D. Welty and J. Schooley

Story in Brief

The data were collected from 463 purebred and crossbred gilts of Duroc, Yorkshire, Landrace and Spot breeding farrowed during fall 1976 and spring 1977. All gilts were fed *ad libitum* either on pasture or in confinement. When gilts reached 200 lb, they were weighed off test and placed in dirt lots. After the gilts were taken off test they were limit fed (approximately 5 lb/day) and checked daily for expression of first estrus. First estrus was considered to have occurred when a gilt would first stand to be mounted by a teaser boar. For the purpose of the study, first estrus was used to define puberty.

The breed of sire had no significant effect upon age at first estrus. However, breed of sire did significantly affect weight at first estrus. Landrace sired gilts were the lightest and Duroc sired gilts the heaviest at first estrus (206.6 and 218.8 lb, respectively). Breed of dam significantly affected both age at first estrus and the number of days from when gilts were removed from test until expression of estrus. Age at first estrus was lowest for gilts from Spot and Duroc dams (188.8 and 189.8 days, respectively), followed closely by Landrace (191.9 days) and then gilts from Yorkshire dams (197.6 days).

Landace and Yorkshire sired gilts which were fed in confinement expressed estrus earlier than the Landrace and Yorkshire sired gilts which were fed on pasture. However, Duroc sired gilts reached puberty earlier if fed on pasture than if fed in confinement. Spot sired gilts expressed estrus at similar ages on either system.

Crossbred gilts were 6.3 days younger and were 2.2 lb heavier at first estrus than purebred gilts. Spring farrowed gilts expressed estrus 5.8 days earlier and weighed 7.3 lb more at first estrus than fall born pigs. Gilts fed in confinement were penned next to boars of a similar age and gilts on pasture were fed together with barrows. Gilts in confinement were 4.3 days younger and 4.6 lb lighter at first estrus than those fed on pasture.

Seven percent of the gilts farrowed in the fall of 1976 were not detected in estrus compared to 11.6 percent of the gilts farrowed in the spring of 1977. Estrus was observed in 92.9 percent of the crossbred gilts compared to 84.7 percent of the purebreds. Management systems did not affect the percentage of gilts exhibiting estrus.

Introduction

as swine production became more intense, there was increased interest in maximizing productivity. Reducing the age at when gilts are bred, without any significant reduction in their performance, can result in savings of both feed and labor. Some environmental factors which have been found to reduce age at puberty include fenceline contact between gilts and boars, daily exposure of gilts to a teaser boar, moving gilts and mixing gilts together.

It is also important to understand the genetic factors associated with age at puberty. Accurate estimates of heritability will determine the opportunities to reduce age at puberty by selection. Previous research has shown large genetic differences between breeds for some factors associated with reproductive performance. However, there is little information currently available regarding breed differences for age and weight at puberty. Since crossbred females have proven to be superior to purebreds for reproductive performance, a comparison of the different two-breed crosses is necessary for these traits.

Therefore, the purpose of this paper is to provide a preliminary comparison of purebreds and crossbreds of Duroc, Yorkshire, Landrace and Spot breeding for age and weight at puberty. This information may be valuable when analyzing mating systems which will maximize overall efficiency of production.

Experimental Procedure

The data were obtained from 463 gilts which were purebred and two-breed crosses of Duroc, Spot, Yorkshire and Landrace breeding. The gilts were raised at the Stillwater Experimental Swine Farm during the fall of 1976 and spring 1977. They were produced by randomly mating boars of each breed to at least one female of each of the four breeds. Information on the mating structure, management of sows and litters and growth characteristics of the gilts can be found in the two preceeding papers in this report.

The pigs were all farrowed in a central farrowing unit and weaned at six weeks of age. Creep was provided at approximately 21 days of age. Two weeks after weaning, gilts were randomly allotted within litters to either of two management schemes, pasture or confinement finishing. All gilts were fed *ad libitum* until they reached 200 lb, at which time they were weighed off test and probed for backfat. The gilts were then grouped and placed in pasture lots. After placement in pasture lots, gilts were checked daily for estrus activity with the aid of a teaser boar. For the purpose of the study, puberty was defined as a gilt's first detectable estrus (indicated by a standing response when mounted by a teaser boar). Age and weight were recorded when gilts expressed their first estrus. Each season gilts were checked daily until the youngest gilts were approximately 7½ months of age. (The youngest gilts were 219 days of age in each of the seasons). The number of days and weight gain from the time the gilts were removed from test until they expressed estrus was also noted. Gilts which displayed obvious signs of disease, lameness or died before reaching 219 days of age were omitted from the analyses.

Results and Discussion

Breed group means and comparisons among purebreds and crossbreds are presented in Table 1. Crossbreds exhibited estrus at an earlier age than purebreds (190.4 *vs* 196.7 days). Crossbreds were 2.2 lb heavier than purebreds at first observed estrus which was due to a slightly greater gain from when they were removed from test to when they were first observed in estrus. In addition, a higher percentage of purebred gilts than crossbred gilts were never observed in estrus (15.3 percent *vs* 7.1 percent).

The range in age for the 43 gilts which were not observed in estrus was 219 to 285 days with a mean of 242.7 days. The range in age for gilts that did exhibit estrus was 147 to 274 days with a mean of 192.0 days. Eighty-seven percent of the gilts which were detected in estrus were less than 219 days old at first observed estrus. It appears that adequate time was allowed for most gilts to express estrus.

Breed of sire did not significantly affect age at first estrus, however, breed of sire did significantly affect weight at first estrus (Table 2). Weight at puberty for Landrace sired gilts was 12.2 lb less than for Duroc sired gilts (206.6 and 218.8 lb, respectively). Although not significant, the number of days from when removed from test until expressions of estrus was shorter for gilts sired by Landrace (22.4 days) and Spot (21.5 days) than for those sired by Duroc or Yorkshires (26.1 and 25.9 days, respectively). The reduction of time from removal from test to expression of estrus coincided with a reduction in weight gain for the same period.

Breed of dam significantly affected both age at puberty and the number of days from when gilts were removed from test to expression of estrus (Table 3). Generally, gilts from the breed of dam requiring fewer days from when removed from test to expression of estrus also were younger at first estrus. The mean age at first estrus was lowest for gilts from Spot (188.8 days) and Duroc dams (189.7 days) which were followed closely by gilts from Landrace dams (191.9 days) and then gilts from Yorkshire dams (197.6 days).

A significant interaction existed between breed of sire and management system (pasture or confinement). Both Yorkshire (185.7 *vs* 199.2 days) and Landrace (188.0 *vs* 195.6 days) sired gilts expressed estrus at a younger age when fed in confinement than when fed on pasture. Gilts sired by Spots responded similarly in either pasture or confinement (189.2 and 189.3, respectively). On the other hand, Duroc sired gilts that were fed on pasture were somewhat younger at first estrus that those which were fed in confinement (192.3 *vs* 195.7 days). No interaction was evident for weight at first estrus.

Table 1. Average performance for gilts of each breed group

Breed Group	No.	Age at Puberty (days)	Weight at Puberty (lb)	Days[b]	Gain, lb[b]	Number of undected[c]
Duroc	36	197.0	220.2	27.0	15.5	10
Yorkshire	26	200.7	204.9	29.8	4.7	6
Landrace	34	195.4	205.3	20.2	4.7	1
Spot	28	195.1	210.8	20.7	11.8	2
DxY	62	197.9	223.0	33.0	22.8	6
DxL	55	186.2	204.6	19.5	6.6	6
DxS	51	185.2	215.7	21.0	12.0	0
YxL	54	196.5	213.1	27.3	12.2	4
YxS	60	187.1	209.9	20.6	9.0	7
LxS	57	188.7	207.6	21.2	5.6	1
Purebreds	124	196.7*	210.2	23.8	9.1	19
Crossbreds	339	190.4	212.4	23.9	11.4	24

[a]Reciprocals combined (D–Y = DxY and YxD).
[b]Days and gain from when gilts were removed from test to expression of estrus.
[c]Number of gilts which were not observed in estrus. Youngest gilts were 219 days of age when estrus detection was terminated.
*Difference between purebreds and crossbreds significant (P<.05).

Table 2. Average performance of gilts by each breed of sire

Sire breed	No.	Age at Puberty	Weight at Puberty**	Days[a]	Gain[a]**
Duroc	100	194.0	218.8	26.1	16.8
Yorkshire	101	192.9	211.9	25.9	10.9
Landrace	107	192.0	206.6	22.4	6.2
Spot	112	189.3	210.8	21.5	9.9

**Significant (P<.01).
[a]Days and gain are the number of days and weight gain, respectively, from when gilts were removed from test to puberty.

Table 3. Average performance for gilts by each breed of dam

Sire breed	No.	Age at Puberty**	Weight at Puberty	Days[a]**	Gain[a]
Duroc	108	189.7	213.7	24.8	12.3
Yorkshire	98	197.6	214.9	29.5	14.7
Landrace	114	191.9	208.3	21.4	7.8
Spot	100	188.8	211.0	20.2	9.0

**Significant (P<.01).
[a]Days and gain are the number of days and weight gain, respectively, from when gilts were removed from test to puberty.

Spring farrowed gilts were significantly younger at first estrus than fall farrowed gilts (189.0 and 194.8 days, respectively) (Table 4). The spring born gilts were also significantly heavier at first estrus than fall born gilts (215.6 and 208.3 lb, respectively). The heavier weight at first estrus for spring farrowed gilts appeared to be the result of a significant difference in amount of gain from when they were removed from test to expression of estrus.

Table 4. Average performance for gilts born during Fall 1976 and Spring 1977 farrowing seasons

	Fall 1976	Spring 1977
Number	214	206
Age at Puberty Days**	194.8	189.0
Weight at Puberty, lb**	208.3	215.6
Days Off Test	22.8	24.9
Gain, lb*	9.0	12.8
% Undected	7.0	11.6

* Significant difference between seasons (P<.05).
**Significant difference between seasons (P<.01).

Table 5. Average performance for gilts fed on pasture or in confinement

	Pasture	Confinement
Number	218	202
Age at Puberty, Days*	194.0	189.7
Weight at Puberty, lb*	214.1	209.5
Days Off Test	23.0	24.8
Gain, lb	10.9	11.8
% Undected	9.2	9.4

*Significant difference between management systems (P<.05).

In the comparison among management schemes, confinement reared gilts were significantly lighter (4.6 lb) and younger (4.3 days) at first estrus than gilts raised on pasture (Table 5). The validity of the comparison among management schemes should be weighed carefully because gilts in confinement were penned adjacent to boars of similar age; while those on pasture were fed together with barrows. Research has indicated that penning boars adjacent to gilts will reduce age at puberty. Therefore, the results need to be limited to the particular circumstances in which the data were obtained.

This should be considered as a preliminary comparison among these breed groups. Additional replications of this mating structure are being made and will provide more precise comparisons.

Protein and Choline Levels of Gestating Gilts

C. Maxwell, R. K. Johnson and R. Vencl

Story in Brief

The effect of protein level and choline supplementation on weight gain, conception rate and subsequent reproductive performance was evaluated in a total of 214 gilts in the 1976 fall and 1977 spring farrowing seasons. The gilts were fed either a 12 or 16 percent crude protein ration containing either a high supplemental choline level or no supplemental choline.

Conception rate was not influenced by either protein or choline level. Gilts fed the higher protein level tended to be heavier at breeding and at 110 days of gestation.

Although not significant, litter size was consistently larger in gilts fed the higher level of protein or choline. These differences at 21 and 42 days ranged from 0.42 to 0.50 pigs per litter.

Differences in pig birth weight and litter birth weight due to protein approached significance although the differences were small. By 42 days, the litters from gilts fed 16 percent crude protein were 12.4 lb heavier than litters from gilts fed 12 percent crude protein and litters from gilts fed the higher choline were 13.1 lb heavier than litters from gilts fed no supplemental choline.

Introduction

Several recent studies have shown that supplemental choline in the diet of gestating sows fed corn-soybean meal diets results in an increase in litter size and conception rate. Since milo contains more choline than corn, it is possible that choline supplementation may not be as critical in sows fed milo based diets.

Studies in the growing pig indicate that the dietary requirement of choline can be replaced by high levels of dietary methionine or protein. The effect of protein on the choline response observed in gestating sows has not been studied.

This study was conducted to evaluate the effect of dietary protein and choline in gilts fed a milo-soybean meal based diet during gestation on weight gain, conception rate and subsequent reproductive performance.

In cooperation with USDA, Science and Education Administration, Southern Region.

Table 1. Composition of experimental rations

Ingredients	12% CP 0 choline	12% CP + choline	16% CP 0 choline	16% CP + choline
Milo	86.31	86.31	75.17	75.17
Soybean meal (44%)	10.02	10.02	21.32	21.32
Dicalcium phosphate	1.66	1.66	1.42	1.42
Calcium carbonate	1.01	1.01	1.09	1.09
Salt	0.50	0.50	0.50	0.50
Vit T.M. premix[a]	0.50	0.50	0.50	0.50
Auro SP-250[b]	+	+	+	+
Total	100.00	100.00	100.00	100.00
% crude protein calculated	12.0	12.0	16.0	16.0
Mg/lb supp choline 1976-Fall	0	0	400	400
Mg/lb supp choline 1977-Spring	0	0	250	250
% calcium, calculated	0.75	0.75	0.75	0.75
% phosphorus, calculated	0.60	0.60	0.60	0.60

[a]Supplied in addition to choline 3,000,000 IU Vitamin A, 300,000 I.U. Vitamin D, 4 gm riboflavin, 20 gm pantothenic acid, 30 gm niacin, 15 mg Vitamin B_{12}, 6,000 IU Vitamin E, 2 gm menadione sodium bisulfite, 0.2 gm iodine, 90 gm iron, 20 gm manganese, 10 gm copper and 90 gm zinc per ton of feed.
[b]ASP-250 was provided at the rate of 5 lb/ton in all rations throughout the experiment.

Experimental Procedure

This study was conducted at the Southwestern Livestock and Forage Research Station swine facilities in the 1976 fall and 1977 spring farrowing seasons. A total of 214 gilts were randomly allotted from within breed group to four treatments consisting of two levels of protein (12 percent and 16 percent; Table 1) and two levels of choline (0 supplemental choline and 400 mg/lb supplemental choline in 1976 fall and 250 mg/lb supplemental choline in 1977 spring) in a 2 × 2 factorial experiment. Gilts were maintained in dirt lots and were group fed approximately 4.5 lb/head/day. The gilts were fed a 16 percent crude protein milo-soybean meal diet with adequate choline prior to the initiation of the trial.

Breeding was started within one week after the trial was initiated in both breeding seasons. Gilts were checked daily for estrus and were hand mated on two consecutive days to the same boar. A two month breeding season began June 1 for the fall farrowing and December 1 for the spring farrowing.

At day 110 of pregnancy, gilts were moved to individual farrowing stalls and litters were penned separately until weaned at 42 days. Beginning on day 110 of gestation all gilts from all treatment groups were fed a 16 percent crude protein lactation diet with 250 mg/lb of supplemental choline throughout lactation. Therefore, any effects on lactation were carry-over effects from the diet during gestation.

Table 2. The effect of dietary protein and choline level on conception rate and weight gain of gilts

Protein level	12% Protein		16% Protein		Sig.
Choline level	0 choline	+ choline	0 choline	+ choline	Level
No. gilts	54	55	55	50	
1st serv conc rate[a]	70.4	67.3	74.5	70.0	NS
Conc rate[b]	83.3	89.1	89.1	90.0	NS
Breeding wt	272.3	280.5	291.7	282.7	Prot., P<.07
110-day wt	367.8	371.9	394.1	377.4	Prot. P<.05
Gestation gain	95.5	91.5	102.2	94.8	NS
Weaning wt	366.2	358.4	380.4	367.3	NS
Lact gain	0.1	−12.9	−13.8	−9.5	NS

[a]Percentage of gilts which farrowed a litter after one mating period.
[b]Percentage of gilts which farrowed a litter of pigs.

Results and Discussion

The effect of choline and protein level fed during gestation on conception rate and gilt weight changes are listed in Table 2. No significant differences were observed in either first service conception rate or overall conception rate. Other workers (Stockland and Blaylock, 1974) have observed a decrease in conception rate in gilts fed a corn-soy diet with no supplemental choline. In their studies, however, the low choline diet was started 6 to 8 weeks prior to the initiation of breeding.

Gilts fed the 16 percent protein diet were approximately 10 lb heavier at breeding (P<.07) and 15 lb heavier at 110 days of gestation (P<.05) than gilts fed the 12 percent protein diet. However, no significant differences were observed in the weight of gilts at weaning or in gestation and lactation weight changes. The low level of protein fed prior to breeding and during gestation may not have supported maximum gain.

Choline had no significant effect on gilt weight during either gestation or lactation. This suggests that choline is not needed to attain maximum weight gain in gestating gilts. Since supplemental choline is not required for maximum gain in growing and finishing hogs, no beneficial effect on weight gain in gilts was expected.

Although differences in number of live pigs born, number at 21 days, number at 42 days and survival rate were not significantly affected by either dietary protein or choline, it should be noted that litter size at each of these time periods was larger in gilts fed the higher level of protein or choline (Table 3). The increase in litter size at 3 weeks of age in gilts fed supplemental choline during gestation in this study is similar to the increase observed by the NCR-42 committee on swine nutrition (0.50 pigs per litter, NCR-42 commit-

Table 3. The effect of choline and protein level during gestation upon subsequent litter size and survival rate

	12% Protein		16% Protein		Sig.
	0 choline	+ choline	0 choline	+ choline	Level
No. pigs[a]	10.36	10.78	10.94	10.60	NS
No. 21 days	7.40	8.08	8.12	8.36	NS
No. 42 days	7.16	7.81	7.87	8.06	NS
Survival rate, %	68.70	72.97	72.78	76.14	NS

[a]Number of fully formed pigs.

Table 4. The effect of protein and choline level during gestation on subsequent pig birth weight and gain

	12% Protein		16% Protein		Sig.
	0 choline	+ choline	0 choline	+ choline	Level
Pig birth wt, lb	2.75	2.76	2.75	2.81	Prot., P<.06
Litter birth wt, lb	28.1	29.2	30.0	29.6	Prot., P<.08
Pig 21-day wt, lb	10.3	10.6	10.3	10.6	NS
Litter 21-day wt, lb	76.5	86.1	84.6	88.9	NS
Pig 42-day wt, lb	21.7	22.1	22.0	22.6	NS
Litter 42-day wt, lb	155.5	172.5	171.8	180.9	Prot., P<.04 Chol., P<.07

tee on swine nutrition, 1976). Litter size at both 21 and 42 days was also higher (0.50 and 0.48 pigs per litter, respectively) in gilts fed the 16 percent protein gestation diet than in gilts fed the 12 percent protein diet. Survival rate ranged from a low of 68.7 percent in pigs from gilts fed both low protein and no supplemental choline to a high of 76.14 percent for pigs from gilts fed the high protein diet with supplemental choline.

The effect of protein and choline level during gestation on subsequent pig birth weight and gain are shown in Table 4. Although differences are small, feeding a higher protein diet during gestation increased pig birth weight (P<.06) and litter birth weight (P<.08). This trend for increased litter weight in pigs from gilts fed the higher level of protein during gestation was observed at both 21 and 42 days (5.45 and 12.4 lb/litter heavier, respectively) although differences were significant only at 42 days. Differences in pig weight at 21 and 42 days were not significant.

Litters from gilts fed the supplemental choline during gestation were 13.1 lb heavier (P<.07) at 42 days than litters from gilts with no supplemental choline. This overall effect is due to both a slight increase in survival rate and pig weight. The data from this trial suggest that supplemental choline and a level of protein higher than a 12 percent crude protein milo-soybean meal diet during gestation are essential in order to maintain maximum reproductive performance.

Table 5. The effect of protein and choline level during gestation on the spraddle leg condition in newborn pigs

	12% Protein		16% Protein	
	0 Choline	+ choline	0 choline	+ choline
No. gilts farrowing	45	49	49	45
No. gilts with one or more spraddle leg pigs	5	7	3	3
No. live pigs farrowed with spraddle legs	6	7	5	5

The incidence of spraddled leg pigs was very low in all treatments (Table 5). No differences in the number of sows farrowing pigs with spraddle legs or number of pigs with spraddle legs due to level of choline or level of protein were observed. One or more spraddled leg pigs was observed in 8.5 percent of the litters from sows fed 0 supplemental choline and 10.6 percent of the litters from sows fed supplemental choline.

Literature Cited

NCR-42 Committee on Swine Nutrition. 1976. Effect of supplemental choline on reproductive performance of sows: A cooperative regional study. J. Anim. Sci. 42:1211.

Stockland, W.L. and L.G. Blaylock. 1974. Choline requirement of pregnant sows and gilts under restricted feeding conditions. J. Anim. Sci. 39:1113.

SHEEP

Rearing Orphan Lambs By Using Adoption Stalls

J. V. Whiteman and J. Fields

Story in Brief

During the 1977 winter and following fall lambing seasons a system of adoption stalls were tried to determine whether orphan or extra lambs could be grafted on ewes that only had one lamb or had lost their lambs. The winter lambing season involved 438 live lambs (many twins, triplets and quadruplets) from which there are records of 29 attempts to have lambs adopted. The fall lambing season involved 130 live lambs with six recorded adoption attempts. Most of the ewes used as foster mothers were ewes with a single lamb although a few were ewes that had lost a lamb or lambs.

The system described was usually quite successful if the lamb involved was strong and the ewe had sufficient milk. This method requires less labor and is probably more "foolproof" than most methods of rearing orphans or extra lambs. It is also cheaper and more successful.

Introduction

Anyone with much experience in raising sheep has gone through the ordeal of trying to raise the orphan lambs that result from ewes with no milk or too many lambs, ewes that will not claim their lambs or ewes that die. Many schemes have been tried for rearing these orphans or getting other ewes to adopt them. Recently there have been excellent but expensive powdered milks available and lamb nursery methods have been developed. Most if not all previous methods of rearing these lambs have one or both of two drawbacks, ie., they are expensive in time and/or money.

During the summer of 1976, an acquaintance told of seeing a scheme in Europe that was highly successful. It involved an adoption stall or crate where a ewe was placed with the lamb(s) that she was to raise. The stall had a stanchion to control the ewe's position and to prevent her from knowing what lamb was attempting to nurse. The ewe and lamb(s) remained in the stall for five days during which time the ewe was fed and watered but the animals were otherwise left alone. Supposedly the system worked well if started within five days after a ewe lambed or within five days after orphans were born.

This report describes the experiences with one of these systems at the Southwest Livestock and Forage Research Station during two lambing seasons.

Materials and Methods

A battery of nine adoption stalls were designed and built prior to the February-March 1977 lambing season. (The estimate was made that nine stalls would be sufficient for the 250 ewe flock. It was adequate.) Each stall was 32″ wide by 48″ long and constructed of plywood. The front of the stall was solid except for a vertical section (8″ × 36″) which was removed. One side of this opening became the permanent side of the stanchion and an adjustable ¾ inch pipe was the movable side of the stanchion (Figure 1). A 4′ × 8′ plywood served as the front for three stalls. The partitions between stalls were hinged to the front. The partitions were 48″ long and 32″ high. A door was hinged to the back of each partition to serve as the back of the stall.

During the lambing season from February 10 until March 27 there were 238 ewes that lambed with 65 singles, 148 sets of twins, 26 sets of triplets and 5 sets of quadruplets. The plan was to use the stalls to get ewes with single or no live lambs to accept and raise extra lambs. Ewes that did not want to raise their lambs were also put in the stalls.

Ewes were fed and watered in containers in front of their stalls and were tethered in their stanchions for four days. After four days they were released from the stanchion but remained in their stalls. If they appeared to accept their lambs, they were turned into a small pen with a few other ewes and their lambs after the fifth day. Ewes that did not want to accept lambs were stanchioned again.

During the October-November 1977 lambing season the stalls were again utilized but there were only 137 lambs born from 99 ewes lambing. With fall lambing there are less multiple births (one set of triplets and 36 sets of twins), lambs are smaller (fall born lambs average two lb less at birth) and more ewes do not have much milk at lambing time as compared to the same kind of ewes lambing during the spring. Of 438 lambs born alive during the February-March lambing we lost five percent during the first two weeks and we lost nine percent of the 130 live lambs born during the October-November lambing.

Results and Discussion

It is difficult to summarize experiences such as these. Each lamb and ewe where an adoption was attempted represented a unique situation. The following statements best characterize our experiences.

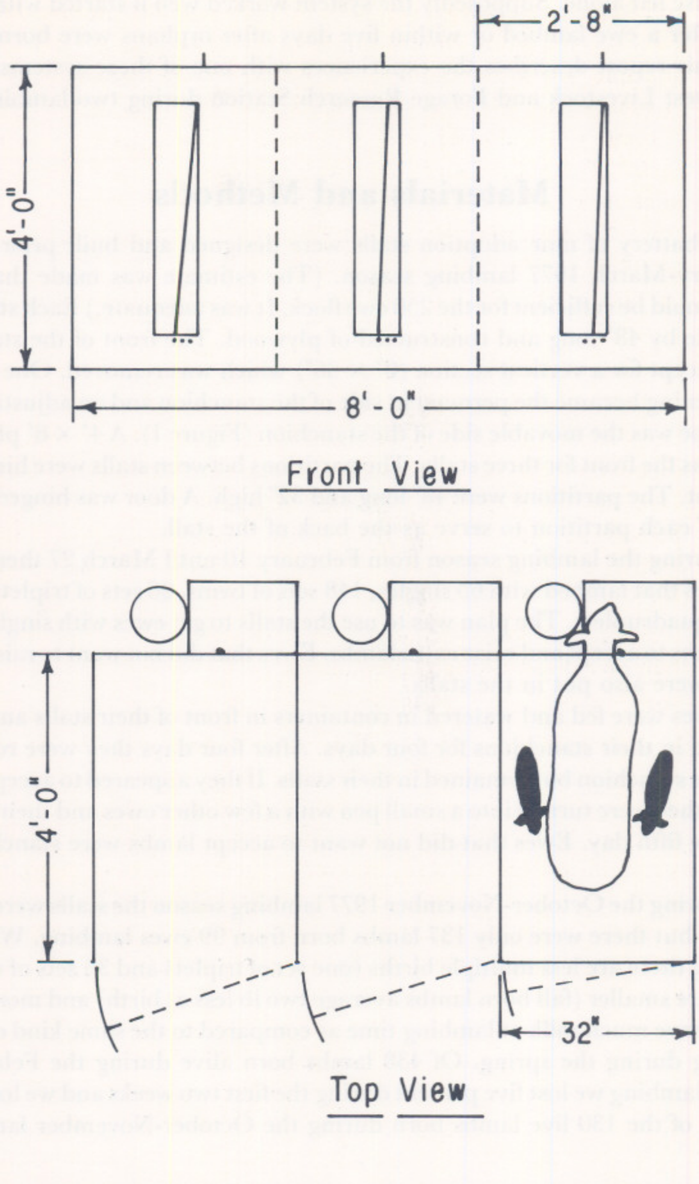

Figure 1. TOP: View of 4′ × 8′ plywood ¾ inches thick which serves as the front for three stalls. Openings hold a ¾ inch pipe bolted at the bottom to serve as the movable side of the stanchion.
BOTTOM: Top view of three stalls showing feed and water location and hinged gate at back of stall.

1. In 29 cases ewes with a single lamb were used as foster mothers for a second lamb usually smaller than hers because it was a multiple. These differences in birth weight were a great as 7-8 lb in some cases. Three of these lambs were apparently accepted but later rejected and in two of these cases there was a mismatch in size. Two of the foster lambs were laid on in the stall, one was a weak multiple and the other appeared to be an accident. The other 24 lambs were accepted and reared in what varied from an adequate manner to an excellent manner.
2. In three cases ewes that had lost a single lamb took another with no apparent problem.
3. Two out of three ewes that had produced multiples and lost one or more did not succeed as foster mothers.
4. The stalls were used to get several ewes to accept their lambs but we have no records to show how many such cases there were.
5. Generally the adopted lambs did not gain as well to weaning as did the foster mothers' own lambs. However, the adopted lambs were smaller in most cases and thus expected to gain at a slower rate.
6. The saving in labor by using this system is far more important than any disadvantages encountered.

Comments

Experience with this system will no doubt further improve its effectiveness. Probably there should not be a hard and fast procedure for all lambs. A good shepherd will recognize the individual problems that will exist in individual cases and make necessary procedural adjustments.

This general system but with different stall or stanchion plans has been tried in other experimental flocks and the results have been as good or better than ours. It would appear that the only lambs which should be bottle reared or put in a nursery on artificial milk are where ewes with adequate milk and spare nipples are not available.

Comparison of Feed Efficiency for Two Weight Intervals and Carcass Composition at Two Market Weights Of Ram and Ewe Lambs

R.D. Herriman, R.L. Adams, L.E. Walters, J.V. Whiteman and J.E. Fields

Story in Brief

Feed efficiency and carcass composition of 60 ram and 60 ewe lambs slaughtered at 100 and 125 lb were determined. The animals were obtained from an eight month lambing interval project in progress at the Southwest Livestock and Forage Research Station, El Reno, Oklahoma. Equal numbers of lambs, both rams and ewes, were used from each of three lambing seasons - fall, summer and spring. All lambs were the progeny of crossbred dams of various levels of Rambouillet, Dorset and Finnsheep breeding mated to Hampshire, Suffolk or blackfaced crossbred rams.

Feed efficiency data were calculated for the ram and ewe lambs for two different weight gain intervals (70 to 100 lb and 100 to 125 lb live weight). Carcass measurements were taken and carcass composition data obtained at two slaughter weights (100 and 125 lb).

The average pounds of feed required per pound of gain was lower for ram lambs than for ewe lambs within their respective weight gain intervals. Ram and ewe lambs fed from 70 to 100 lb required about 2½ lb less feed per pound of gain than ram and ewe lambs fed from 100 to 125 lb. Rams gained about ¼ lb per day more than ewes in both weight gain intervals. Ram and ewe lambs fed from 70 to 100 lb gained about 0.12 lb per day faster than ram and ewe lambs fed from 100 to 125 lb.

Slaughter and carcass data show that ram lambs were lower in all fat measurements, yield grade, quality grade and dressing percentage, but nearly equal in rib eye area to ewe lambs. Additionally, light weight lambs, both rams and ewes, were lower in all fat measurements, U.S.D.A. grades, rib eye area and dressing percentage than heavier lambs. Carcass composition data clearly indicates that rams yield more of their carcass weights in closely trimmed major wholesale cuts, considered to be the best measure of retail value, than ewe lambs. The data also indicate that heavier lambs yield less in percent trimmed wholesale cuts than lighter lambs, but this difference is nearly two times greater in ewe lambs than ram lambs (3.0 *vs* 1.7). Nevertheless when the closely trimmed major wholesale cuts were expressed as a percent of live weight, there was little or no difference between ram and ewe lambs or

between weight groups within sex (about 30.0 percent). Since the principal factor determining the value of live lambs is the percent of retail product, this suggests that the value per pound alive should be similar for rams and ewes, light and heavy if the selling price of the retail cuts from these lambs is the same.

Introduction

Lamb as a meat source has fallen to its lowest per capita consumption (1.3 lb) in recorded American history. One logical explanation for this is the continual decrease in sheep numbers since the mid 1940's causing a low supply of lamb in the retail meat counters. The fact that the supply of lamb is low has been reflected in the price of market lambs sold through lamb markets and in the retail price for lamb in retail stores.

Several methods for the American sheep industry to alleviate this short supply situation have been outlined in the national "Blueprint for Expansion." These include increasing ewe numbers, increasing percent lamb crop weaned and increasing market weight per lamb. The one alternative that would be the quickest and easiest, with the present supply of live lamb, is simply to increase the slaughter weight of lambs above the traditional 100 lb.

Even though increasing slaughter weight provides a quick way for increasing the supply of lamb, there are problems when lambs are fed to heavier weights. The two most influential problems are the increase in fat deposition and decrease in feed efficiency as slaughter weight increases.

Whether or not heavier lambs will be used to increase the supply of lamb will depend upon the amount of feed required per extra pound of edible meat and the effect on the desirability of retail cuts due to the increase in fat content in heavier lambs.

The objectives of this study were (1) to determine the amount of extra feed required per pound of extra live weight gain for ram and ewe lambs fed from 100 to 125 lb as compared to ram and ewe lambs fed from 70 to 100 lb, and (2) to determine how much of an effect slaughter weight has on the yield of percent closely trimmed major wholesale cuts of ram and ewe lambs.

Materials and Methods

Crossbred ram and ewe lambs, produced from the matings of Suffolk, Hampshire, Suffolk X Hampshire or Hampshire X Suffolk sires with dams of various levels of Rambouillet, Dorset and Finnsheep breeding were selected from an eight month lambing interval project in progress at the Southwest Livestock and Forage Research Station at El Reno, Oklahoma. Dams of those breed groups have previously been shown not to have an appreciable affect on differences in carcass composition of their lambs.

Twenty ram and 20 ewe lambs were selected from each of three lambing seasons - fall of 1975, summer of 1976 and spring of 1977. From each season there were two pens of 10 ram lambs each and two pens of 10 ewe lambs each. (One ewe lamb from the fall crop prolapsed and was eliminated from the study.)

Each pen of lambs was selected from the experimental flock when 10 rams or 10 ewes were found such that the average weight of the pen was approximately 70 lb and each lamb in the pen weighed as close to 70 lb as possible. As each group of 10 lambs was selected, that pen was placed in drylot and fed a ration consisting of 45 percent alfalfa, 50 percent milo and 5 percent molasses.

During the early part of the feeding period, individual weights were obtained on a weekly basis. When the average weight of the pen neared 100 lb, individual weights were obtained twice weekly in order to slaughter a group of five lambs at an average weight as close to 100 lb as possible. When the average weight of the pen of lambs reached 100 lb, five of the lambs that would represent the average weight of the pen (100 lb) were selected for shipment to the Oklahoma State University Meat Laboratory for slaughter. The remaining five lambs were sheared, then fed and weighed in the same manner as above to a slaughter weight of 125 lb minus their wool weight.

A total of six pens of rams and six pens of ewes were fed over three seasons. Feed efficiency values were calculated for each pen rather than for individual lambs. Thus, for the lower weight interval (70 to 100 lb) each sex calculation represents 60 lbs, and for the heavier weight interval (100 to 125), 30 lambs.

After slaughter, the carcasses were chilled for 24 hr at 34 F. Carcasses were then wrapped with two layers of beef shrouds to decrease dehydration of the lamb carcasses until the carcasses were cut. U.S.D.A. quality grade was determined prior to cutting each carcass. Other carcass data obtained were dressing percent, rib eye area and U.S.D.A. yield grade factors (12th rib fat thickness, percent kidney and pelvic fat, and leg conformation score) from which actual U.S.D.A. yield grades were estimated.

The right side of each carcass was broken into the major wholesale cuts of leg, loin, rack and shoulder. All external fat was removed from each cut. The leg and shoulder were then physically separated into their lean, fat and bone components. Yield of trimmed and boned leg and shoulder, trimmed rack and loin, and trimmed yield of these four cuts were calculated on both a carcass and a live weight basis.

Results and Discussion

Feed efficiency

The characteristic of greatest interest for determining the productive efficiency of light lambs *vs* heavy lambs is the amount of feed required per unit of live weight gain to take lambs to heavier weights. This measure is closely related to daily feed intake and average daily gain. Averages for daily feed intake, average daily gain and pounds of feed per pound of gain per season and their averages for the three seasons are presented in Table 1 for ram and ewe lambs fed for two weight gain intervals.

Daily feed intake was about 0.4 greater for the rams than for the ewes from 70 to 100 lb. However, after reaching 100 lb, the increase in daily consumption by the rams was three times greater than the increase by the ewes (1.2 lb *vs* 0.4 lb). This phenomenon often occurs since, generally, as animals become fatter, they tend to decrease their feed intake, and the carcass data on these lambs (discussed later) clearly shows that the ewe lambs were, in fact, much fatter than the ram lambs at 100 lb.

Rams had about on 0.25 ADG advantage over ewes within both weight gain intervals, and the average daily gain decrease after reaching 100 lb was nearly the same (0.13 and 0.09 lb) for both ram and ewe lambs. Feed efficiency was much more favorable for the ram lambs than for the ewe lambs within each weight interval. Additionally, feed efficiency for ewes between 100 and 125 lb from season to season was extremely variable. Consequently, it becomes important to consider over-all averages when applying the data because of the relatively small numbers on test during each season.

The data in Table 1 indicates the relative daily gain and feed efficiency for typical crossbred market lambs in Oklahoma. Whether or not a producer wishes to feed to heavier market weights will depend, then, upon his feed costs. Obviously, since ram lambs are much better converters of feed into edible meat, they can be fed to heavier weights more economically than ewes.

Carcass characteristics

Typical carcass measurements and grade evaluations for ram and ewe lambs slaughtered at 100 and 125 lb are presented in Table 2. When comparing ram lambs to ewe lambs, rams were about two-thirds of a grade lower in quality grade at the lower market weights, but one and a quarter grades lower at the heavier market weight. Furthermore, ram lambs were consideraly lower (3.75 percent) in dressing percent, lower in all fat measurements and one to one and half grade lower in yield grade than ewe lambs. (A yield grade #1 is exceptionally lean and a yield grade #5 is quite fat.)

Lighter ram lambs were trimmer in all measurements, two-thirds of a grade lower in yield and quality grade, and three percent lower in dressing percent than heavier ram lambs. Lighter ewe lambs were lower by one quality grade and one yield grade, and three percent lower in dressing percent than heavier ewe lambs, but were trimmer in all fat measurements. Rib eye areas were virtually the same for both ram and ewe lambs but differed between weight groups within sex. Heavier lambs in both sexes had about the same (0.28 sq in and 0.29 sq in) increase in rib eye area over lighter lambs.

According to the dictates of the present day marketing system, the 125 lb ram lambs would actually be a more acceptable lamb in quality grade and fat cover than the 100 lb ram lambs to the packer. However, ewe lambs at the

Table 1. Feedlot performance of ram and ewe lambs from three different lambing seasons fed for two different weight gain intervals

Item	Sex	Season I[1] Wt. gain interval (lb) 70-100	100-125	Season II[2] Wt. gain interval (lb) 70-100	100-125
Daily feed intake (lb)	R	4.47	6.08	4.14	5.24
	E	4.38	4.58	3.59	4.43
Avg. daily gain (lb)	R	0.88	0.80	0.75	0.61
	E	0.67	0.57	0.56	0.36
Lb feed/lb gain	R	5.14	7.61	5.52	8.59
	E	6.58	8.12	6.50	12.29
	Sex	**Season III[3] Wt. gain interval (lb) 70-100**	**100-125**	**Average[4] Wt. gain interval (lb) 70-100**	**100-125**
Daily feed intake (lb)	R	4.47	5.48	4.36	5.60
	E	3.79	3.89	3.92	4.30
Avg. daily gain (lb)	R	0.92	0.77	0.85	0.72
	E	0.53	0.56	0.58	0.49
Lb feed/lb gain	R	4.86	7.16	5.17	7.78
	E	7.37	8.28	6.82	9.56

[1]Lambs born in fall 1975
[2]Lambs born in summer 1976
[3]Lambs born in spring 1977
[4]Average over the three seasons

Table 2. Averages for fat measurements, yield grade, quality grade, rib eye area and dressing percent for ram and ewe lambs slaughtered at two live weights

Item	Ram Lambs Approx. live wt. (lb) 100	125	Ewe Lambs Approx. live wt. (lb) 100	125
12th rib fat th. (in)	0.18	0.26	0.30	0.43
% K&P fat	2.85	3.60	4.17	5.38
USDA yield grade	3.01	3.70	4.07	5.25
USDA quality grade[1]	11.30	11.90	12.00	13.13
Rib eye area (sq in)	2.12	2.40	2.08	2.37
Dressing percentage	48.70	51.64	52.44	55.53

[1]14 = Avg. Prime; 13 = Low Prime; 12 = High Choice; 11 = Avg. Choice

heavier market weight were definitely overfinished and undesirable to all segments of the American sheep industry, the producer, packer and consumer.

Table 3 presents the yields of trimmed and boned leg and shoulder, trimmed rack and loin and percent trimmed major cuts, which includes the leg, shoulder, rack and loin on a carcass weight basis. When expressed as a percentage of carcass weight, percent trimmed and boned shoulder and leg decreased for both ram and ewe lambs from a 100 lb slaughter weight to a 125 lb slaughter weight. Lighter ram lambs were higher in precent trimmed rack

Table 3. Trimmed major cuts as a percent of *carcass weight* of ram and ewe lambs slaughtered at two live weights

	wt. (lb)		wt. (lb)	
Carcass cut	100	125	100	125
Trimmed & boned shoulder[1]	15.18	14.57	13.45	12.78
Trimmed rack[2]	8.09	7.82	7.51	7.48
Trimmed loin[2]	13.13	12.92	13.19	12.35
Trimmed & boned leg[1]	18.56	17.48	17.67	15.83
Trimmed major cuts[3]	66.91	65.19	63.70	59.68

[1]Completely lean, fat and bone separated
[2]Closely trimmed and bone in
[3]Closely trimmed and bone in of the four listed cuts

Table 4. Trimmed major cuts as a percent of live weight for ram and ewe lambs slaughtered at two live weights

	Ram Lambs Approx. live wt. (lb)		Ewe Lambs Approx. live wt. (lb)	
Carcass cut	100	125	100	125
Trimmed & boned shoulder[1]	6.82	6.77	6.37	6.51
Trimmed rack[2]	3.56	3.64	3.56	3.79
Trimmed loin[2]	6.09	6.02	6.25	6.29
Trimmed & boned leg[1]	8.34	8.08	8.37	8.08
Trimmed major cuts[3]	30.05	30.17	30.20	30.46

[1]Completely lean, fat and bone separated
[2]Closely trimmed and bone in
[3]Closely trimmed and bone in of the four listed cuts

and loin (about 0.25 percent) than heavier lambs; whereas, lighter ewe lambs were about the same in trimmed rack, but higher in percent trimmed loin (0.74 percent) than heavier ewe lambs. Ram lambs yielded considerably more of their carcass weight in trimmed major cuts than ewe lambs, although the rams had less of an advantage at the lower market weight (2.2 percent at 100 lb slaughter weight and 5.5 percent at 125 lb slaughter weight). Lighter ram lambs were 1.7 percent higher in trimmed major cuts than heavier rams; whereas, lighter ewes were 4 percent higher in percent trimmed major cuts than heavier ewes.

Table 4 represents the same carcass traits as Table 3, but they are expressed as a percent of live weight rather than carcass weight. These data indicate that when percentages of closely trimmed carcass cuts were calculated on a live weight basis, little or no differences were observed for these carcass traits between ram and ewe lambs, or between slaughter weight groups within or between sexes. This was true even though a much higher degree of fatness was attained by both rams and ewes (particularly the ewes) at the higher slaughter weight.

This data further substantiates our expectations that the cut (leg) which has very little intramuscular fat (marbling) or seam fat will decrease slightly as a percent of live weight at heavier market weights; whereas, cuts (especially shoulder and rack) which tend to deposit more fat within and between the muscles as fattening progresses, will have a slightly increased percent of live weight at the heavier weight. Nevertheless, this data convincingly suggests that ram and ewe lambs can be slaughtered at heavier weights without decreasing the percent closely trimmed major wholesale cuts of live weight. Consequently, this fact implies that the live weight price of the heavier and lighter rams and ewes should be similar since the percent of their live weight going through the retail meat counter is nearly equal.

Corn Silage Additives

S. R. Rust, F. N. Owens,
A. B. Johnson, B. J. Shockey
and K. Poling

Story in Brief

Six commercial silage additives and ammonium hydroxide were added to whole plant corn silage and fed to lambs. Feed intakes and gains were slightly greater with addition of most additives or with unfermented frozen chopped corn than untreated silage. Some additives show promise in increasing dry matter digestibility. Laboratory analysis of the treated silages indicated that fermentation increased nutritive value of chopped corn at the expense of available carbohydrates, energy and weight. Ammonium hydroxide increased the crude protein content. Fermentation decreased the time before the onset of mold spoilage. Certain silage additives reduced wet matter loss slightly.

Introduction

The addition of additives to alter the fermentation of ensiled chopped corn plants and to increase its nutritive value has been widely practiced with many different commercial products. Some prolong fermentation, some inhibit fermentation and others add nutrients to improve digestion by the animal. Past research has been inconclusive as to the benefit of additives due to different conditions of ensilage and corn moisture in the treated and untreated materials. The objective of this study was to examine the benefit of several commercially available additives on the nutritive value of ensiled whole plant corn silage by placing the additives on the same chopped material and exposing it to identical ensiling and laboratory conditions.

Materials and Methods

Six commercial silage additives (SJ, SEN, SG, FC IV and SZ) and ammonium hydroxide were added to chopped corn plants (32.2 percent DM) at ensiling in ten double lined plastic bags holding 50 lb each. The control corn silage was allowed to ferment without an additive and one batch of chopped corn was frozen before fermentation. Beginning 284 days later, each of the nine materials was fed to four lambs with a mean weight of 57 lb and intakes were measured for 28 days. The corn silages were *ad libitum* fed with silage weigh-back taken once daily. One-half pound of a 30 percent soybean meal supplement was fed daily. The lambs were weighed every two weeks. The final corn materials were analyzed for dry matter, pH, soluble nitrogen, lactate, energy content, dry matter digestibility and crude protein content. The amount of time before mold growth occurred was measured in a humidor. Feed intake, average daily gain and feed efficiency were determined from the feeding trial. For measurement of energy losses through fermentation, energy content of silage liquids and solids was determined following drying in a special experimental oven. This device, designed by Haskell Edwards, Nutrition Ag. Services, Visalia, California, recondenses the volatiles for measurement.

Results and Discussion

The fresh (unfermented), frozen silage sample dry matter content was higher than all fermented materials. This is due to formation of heat volatile substances and gases by fermentation. The SZ and SG treated silages had lower dry matter content while FC, SJ and SEN had higher dry matter content than the other silage treatments. The pH of the fresh frozen material was higher than the other treatments but lower than neutrality (pH 7.0) suggesting that fermentation had begun between chopping and freezing despite addition of dry ice. The ammonium hydroxide treated corn silage also was higher than the other additives, possibly due to buffering by this material. SEN, SG and FC exhibited lower lactate levels than silage treated with the other four additives, suggesting that fermentation may have been altered by these additives.

The ammonia treated silage had higher and fresh frozen silage had lower crude protein content than other silages. Addition of ammonia would be expected to increase crude protein content and prolong fermentation. The fresh frozen material had lower soluble nitrogen content than fermented material. Solubilization of nitrogen through fermentation is commonly reported. This may act as a non protein nitrogen source in the rumen, but is probably of less value when solubilized than if insoluble and yet digestible in

Table 1. Chemical composition of fermented corn silage

Treatment	Dry Matter (%)	pH	Soluble nitrogen (% of C.P.)	Crude protein (%)	Lactate (% of DM)	Energy content solid (kcal/g)	Energy content liquid (kcal/g)
Fresh frozen control	32.2	4.31	34.4	5.9	0.0	3760	85
Fermented control	29.2	3.74	63.9	7.7	3.1	3931	46
SG	28.7	3.71	61.2	8.0	2.2	3939	95
SZ	28.4	3.72	59.1	7.8	2.6	3881	105
SJ	29.8	3.74	62.9	7.4	2.9	3964	61
IV	28.9	3.69	61.5	7.2	3.7	3860	52
SEN	30.4	3.73	61.3	7.1	2.3	3945	94
NH_4OH	29.1	3.96	63.5	9.3	2.8	4079	63
FC	29.9	3.70	58.3	7.6	1.9	3930	53

Table 2. Feeding trial results with fermented whole corn plant silage

Treatment	Level of addition (lb/ton)	Feed intake (lb DM)	Daily gain (lb/day)	Feed/gain (DM basis)	Digestible organic matter intake (lb/day)	In vitro dry matter digestibility (%)
Fresh frozen control	N/A	1.89	.37	5.3	1.32	67.6
Fermented control	N/A	1.67	.24	6.3	1.12	63.4
SG	1.00	1.72	.37	4.7	1.23	70.2
SZ	.01[a]	1.78	.44	4.3	1.28	68.8
SJ	.75	1.83	.40	4.6	1.28	67.2
IV	1.00	1.87	.35	5.6	1.28	64.7
SEN	.75	1.83	.33	5.9	1.32	70.4
NH_4OH	17.0	1.69	.37	5.1	1.17	64.4
FC	1.00	1.72	.35	5.0	1.23	68.4

[a]Mixed 20 lb of SZ with one ton of wheat middlings, then use one pound/ton of silage.

the intestines. The increase in soluble nitrogen with the silage additives did not appear to depress feed intake by sheep.

All silages with additives had more energy content in the dried solids. This will make feed efficiency when calculated on a dry matter basis higher following fermentation. SG, SZ and SEN appeared to have higher energy content in the volatile liquid fraction.

Feed intake and gains were slightly lower for the fermented control than the fresh frozen or those with additives included. All feed additive silages had slightly increased feed efficiency over the fermented control, but performance data over such a short period with a few lambs is questionable. SG, SZ, SJ, FC and NH_4OH appeared to increase feed efficiency slightly over the fresh frozen control.

Table 3. Storage changes and stability of corn silage.

Treatment	Time to mold appearance (Days)	Losses during storage: Wet matter loss (%)	Dry matter loss (%)	Energy loss (%)	Dig. dry matter change (%)
Fresh frozen control	4	0.0	0.0	0.0	0.0
Fermented control	15	1.3	10.6	8.4	−7.4
SG	9	1.2	11.9	6.6	2.6
SZ	10	1.0	12.6	8.0	0.7
SJ	8	1.0	8.5	4.6	0.0
IV	13	1.1	11.3	10.2	−5.5
SEN	9	0.9	6.6	1.3	3.1
NH_4OH	5	1.0	10.6	4.0	−5.7
FC	7	1.0	8.2	5.5	−0.1

In vitro dry matter digestion suggests SEN and SG increased dry matter digestibility. Fermented corn silage without any additives had the lowest digestibility. Digestible dry matter intake was slightly higher for SEN and fresh frozen control.

In a humidor, ammonia treated and fresh frozen silage spoiled most readily. The silages with the additives added spoiled slightly faster than the fermented control. Wet matter loss during storage was higher for the fermented control suggesting that the additives may have reduced fermentation slightly.

Energy loss during ensiling was higher with IV, SZ and fermented control silages and lower with SEN silage. Dry matter loss during storage was lower with FC, SEN and SJ. Except in one case, energy loss during fermentation was lower than dry matter loss, indicating that energy becomes more concentrated through fermentation. Nevertheless, energy loss through fermentation ranged from 1 to 10 percent of the initial energy content. Besides altering energy loss, additives may influence digestibility of the residue. SG, SZ and SEN appeared to increase total digestible dry matter of forage through fermentation.

These same additives are currently being evaluated with high moisture corn. Further energy retention and digestion trials with several additives for corn silage are planned.

Winter And Fall Lambing Performance Of Crossbred Ewes Of Finnsheep, Dorset, Rambouillet and White Face Western Breeding When Mated To Purebred Or Crossbred Rams

J.M. Dzakuma, D.L. Thomas, J.E. Fields and J.V. Whiteman

Story in Brief

Reproductive performance of four, five and six-year old crossbred ewes representing six combinations of Finnsheep (F), Dorset (D), Rambouillet (R), and White Face Western (WFW) breeding were evaluated when lambing in the winter (February-March, 1977) and in the fall (October-November, 1977). The six breed combinations represented were ⅜F, ⅝WFW; ¼F, ½D, ¼R; ¼F, ¼D, ½R; ¼F, ¾R; ½D, ½R; and ¼D, ¾R. Breeding effectiveness of purebred and crossbred rams of Hampshire and Suffolk breeding was also compared when mated to these ewes.

Results of the winter lambing were more favorable than that of fall lambing with the entire flock averaging 1.8 lambs born per ewe exposed for winter and .53 lambs born per ewe exposed for the fall. Ewes of ⅜F, ⅝WFW breeding had a higher number (2.32) of lambs born per ewe exposed when lambing in the fall. They were followed by ewes of ½D, ½R breeding (1.81), ewes of ¼ Finnsheep breeding (1.74) and ¼D, ¾R breeding were lowest (1.56). When lambing in the fall ewes of ½D, ½R breeding had a higher number (.69) of lambs born per ewe exposed in face of a generally disappointing lamb crop. Ewes of ¼D, ¾R breeding followed with .56; ewes of ⅜F, ⅝WFW breeding had .46 and the average of the three ¼ Finnsheep breeding groups was .46 also.

Comparing September-October, 1976 and May-June, 1977 matings, reproductive performance of ewes when mated to either crossbred or purebred rams in September-October was virtually the same whether measured by percent ewes lambing, lambs born per ewe lambing or lambs born per ewe exposed. For May-June mating, at least 3 out of 4 crossbred yearling rams used outperformed purebreds in getting more ewes settled, in lambs born per ewe lambing, and in lambs born per ewe exposed.

Introduction

An increase in the reproductive rate of the commercial ewe flock offers the greatest single opportunity for increasing the efficiency of lamb meat production. Two desirable ways of increasing reproductive rate are by: 1) infusion of germ plasm of more prolific breeds into our commercial flocks and 2) adoption of some type of accelerated lambing program to shorten interval between lambings.

The commercial sheep industry of Oklahoma and the Southwest has been built around Rambouillet ewes which are relatively long-lived and shear heavy fleeces but are slow maturing and not very prolific. Past research by the Oklahoma Agricultural Experiment Station has shown that crossbred ewes of Dorset X Rambouillet breeding are more productive under Oklahoma farm flock conditions. Broadening the genetic base of ewe flocks by the introduction of the Finnish Landrace (Finnsheep) from Finland, which is noted for its superior lambing rate, is a possible method of improving the productivity of the commercial sheep flocks of the Southwest.

An accelerated program of lambing every eight months may be feasible because ewes have a 5-month gestation period. Research at this station has shown that ewes of Dorset-Rambouillet breeding produce desirable lamb crops when lambing in either the fall, winter or the spring of the year. An early summer lambing is a part of this program.

The purpose of this paper is to compare the reproductive performance of four, five and six-year old crossbred ewes of Dorset and Rambouillet breeding with similar ewes containing ¼ and ⅜ Finnsheep breeding when lambing in the winter and the fall of 1977. Some data is also included on breeding effectiveness of purebred and crossbred rams when mated to these same ewes.

Materials and Methods

During the winter and spring months of 1971, 1972 and 1973 approximately 250 crossbred ewes of six combinations of Finnsheep (F), Dorset (D), Rambouillet (R) and White Face Western (WFW) (a group that were predominantly Rambouillet) breeding were produced at the Southwestern Livestock and Forage Research Station (Ft. Reno), El Reno, Oklahoma. The six breed combinations represented were ⅜F, ⅝WFW; ¼F, ½D, ¼R; ¼F, ¼D, ½R; ¼F, ¾R; ½D, ½R and ¼D, ¾R. Reproductive performance of some of these ewes when lambing in the winter of 1972, 1973 and 1974; the fall of 1974 and 1975 and the summer of 1976 has been reported previously in the Animal Sciences and Industry Research Reports of 1974, 1975, 1976 and 1977.

After each lambing, ewes nursed their lambs for approximately 70 days except that ewes that lambed late had their lambs weaned at younger ages because of the next breeding season. Condition scores and weights were taken on the ewes each time before breeding and before lambing. Scores ranged from one to nine with a score of one indicating a very thin ewe and a score of nine indicating a very fat ewe.

Prior to September 15, 1976 and May 15, 1977 ewes were divided into single sire breeding groups of 32 to 34 and 32 to 33 each for breeding which resulted in the winter and fall, 1977 lambings, respectively. Breeding groups were equalized as closely as possible for number of ewes of each crossbred group and for number of ewes rearing zero, one or multiple lambs the previous lambing. A Hampshire, Suffolk, Hampshire X Suffolk or Suffolk X Hampshire sire was placed with each breeding group for the duration of the 50-day breeding season. The rams used in September and October of 1976 were about 2½ years old. The rams used in May and June of 1977 were about 15-16 months old and inexperienced.

Winter lambing started on February 9, 1977 and continued through March. Fall lambing commenced on October 2, 1977 and continued through November. Ewes lambed under close supervision in a shed or adjacent pasture. Ewes and lambs grazed small grain pasture after the lambs were about a week old. Ewes had access to some dry hay and had about ½ lb of grain per day for a month or two. Lambs had access to creep feed during the preweaning period. At approximately 70 days of age lambs were weaned from their dams except that late born lambs were weaned 4-5 days before ewes were to be bred.

Results and Discussion

Ewe reproductive performance

Lambing performance of the six crossbred ewe groups when lambing in the winter and the fall of 1977 are presented in Table 1. A flock average of 1.8 lambs born per ewe exposed to the rams indicated excellent winter lambing results. Lambing records indicated there were 65 single births, 148 sets of twins, 26 sets of triplets and 5 sets of quadruplets. Fourteen out of the 259 ewes exposed to the rams did not lamb the winter of 1977.

Fertility, as measured by percent of ewes lambing did not differ very much across the six breeds in the winter of 1977. The lowest percent ewes lambing of any breed group was the ¼F, ¼D, ½R group showing 89 percent and ewes of ½D, ½R breeding were most fertile, 96.8 percent (Table 1a). These results are similar to those produced in the winter of 1974 by many of these ewes.

Lambing rate (lambs born per ewe lambing) was very high for the few ⅜F, ⅝WFW ewes (2.4) and lowest for the ¼D, ¾R ewes (1.6). The other ewe groups ranged from 1.7 for the ¼D, ¾R to 2.1 for the ¼F, ½D, ¼R group.

Lambs born per ewe exposed is an overall measure of reproductive performance and a combination of both fertility and lambing rate. Ewes with ⅜F, ⅝WFW had the highest lambs per ewe exposed (2.32) and ewes with ¼D, ¾R had the lowest lambs per ewe exposed (1.56). The other ewe groups ranged from 1.59 for the ¼F, ½D, ¼R to 1.94 for the ¼F, ¾R group. A comparison of ewes containing ⅜ Finnsheep, ¼ Finnsheep, ½ Dorset and ¼ Dorset breeding for lambs born per ewe exposed showed ⅜ Finns doing much better (2.32) followed by ewes of ½ Dorset (1.81), the ¼ Finn ewes were next with an average of 1.74 and ¼ Dorset ewes were the poorest with 1.56. A

Table 1. Lambing performance of the six crossbred ewe groups when lambing in the winter and the fall of 1977

a) Winter 1977 lambing results	⅜F, ⅝WFW	¼F, ½D ¼R	¼F, ¼D ½R	¼F, ¾R	½D, ½R	¼D, ¾R	Total
No. available	25	39	47	34	62	50	259
No. lambing	24	36	42	32	60	52	244
% lambing	96.0	92.3	89.4	94.1	96.8	96.2	94.2
Lambs born	58	62	79	66	112	81	458
Lambs/Ewe lambing	2.42	1.72	1.88	2.06	1.87	1.62	1.88
Lambs/Ewe exposed	2.32	1.59	1.68	1.94	1.81	1.56	1.77
b) Fall 1977 lambing results	**⅜F, ⅝WFW**	**¼F, ½D ¼R**	**¼F, ¼D ½R**	**¼F, ¾R**	**½D, ½R**	**¼D, ¾R**	**Total**
No. available	24	39	47	33	62	52	257
No. lambing	8	13	14	12	32	20	99
% lambing	33.3	33.3	29.8	36.4	51.6	38.5	38.5
Lambs born	11	17	21	16	43	29	137
Lambs/Ewe lambing	1.38	1.31	1.50	1.33	1.34	1.45	1.38
Lambs/Ewe exposed	.46	.44	.45	.48	.69	.56	.53

Table 2. Lambing performance of the crossbred ewes when mated to purebred and crossbred rams of Hampshire and Suffolk breeding during September-October, 1976 and May-June, 1977

	September-October, 1976		May-June, 1977	
	Purebred	Crossbred	Purebred	Crossbred
Rams, no.	4	4	4	4
Ewes exposed, no.	128	131	129	128
Ewes lambing, no.	120	124	32	67
Ewes lambing, %	93.8	94.7	24.8	52.3
Lambs born, no.	224	234	41	96
Lambs/ewe lambing	1.87	1.89	1.28	1.43
Lambs/ewe exposed	1.75	1.79	.32	.75

comparison of ewes of ¼ Finnsheep with ewes of Dorset-Rambouillet breeding only (1.74 *vs* 1.69) did not show a very large difference. The lambing rate for very well (2.42) and in fact did better than all other breeds for the winter 1977 lambing.

Fall, 1977 lambing results are shown in Table 1b. A flock average of .53 lamb born per ewe exposed to the ram was very poor for fall lambing. This was as a result of a low percent of ewes lambing (38.5 percent) for fall, 1977 compared to 94.2 percent of ewes lambing in the winter of 1977. This poor lamb crop could be due to the fact that the breeding records indicated that there was not very intense mating among the females and also due to the fact that the ewes had a very good lambing season the winter of 1977 — that is 8 months prior to lambing in the fall. The breed group comparison for the fall of 1977 lambings followed the pattern of fall lambing results previously reported in Animal Science Research Reports for 1975 and 1976. The same breeding groups tended to be better though all groups gave generally low percent ewes lambing.

Percent of ewes lambing was highest for ewes of ½D, ½R breeding (51.6) and lowest for ewes of ¼F, ¼D, ½R (29.8). Other ewe breeds ranged in fertility from 33.3 for ⅜F, ⅝WFW and for ¼F, ½D, ¼R to 38.5 for ¼D, ¾R.

Lambing rate (lambs born per ewe lambing) did not differ very much between breeds and it ranged from 1.31 for ¼F, ½D, ¼R to 1.50 for ¼F, ¼D, ½R.

The overall measure of reproductive performance (lambs born per ewes exposed) was highest for ewes of ½D, ½R breeding (.69) followed by ewes of ¼D, ¾R breeding (.56). Ewes of ⅜F, ⅝WFW breeding and ewes of ¼ Finnsheep breeding were low with an average of .46 lambs born per ewe exposed.

Purebred *vs* crossbred rams

Table 2 shows the lambing performance of the ewes when mated to either purebred or crossbred rams in September-October, 1976 and May-June, 1977. In the fall breeding season, reproductive performance of ewes mated to purebred or crossbred rams was virtually the same whether measured by fertility (93.8 percent *vs* 94.7 percent) lambs born per ewe lambing (1.87 *vs* 1.89), or lambs born per ewe exposed (1.75 *vs* 1.79).

In the late spring breeding season, crossbred rams did substantially better than purebreds in fertility (52.3 percent *vs* 24.8 percent), lambs born per ewe lambing (1.43 *vs* 1.28), and in lambs born per ewe exposed (.75 *vs* .32). A comparison of individual ram's performance across the breeds for the late spring season, showed at least three of the crossbred rams to have mated more actively than any of the purebreds and the most active purebred ram was better than only the least active crossbred ram. The ewes were also scored for the number of times mated (rams wore marking harnesses) and the records indicated that not very many ewes mated more than once or twice to the ram indicating that the intensity of sexual activity was very low during the late spring.

The fertility obtained in September-October, 1976 mating was similar to that obtained in January-February, 1976 mating. This suggests that a high proportion of the ewes were sexually active in these two seasons and; therefore, there was little difference whether a pure- or crossbred ram was used. The fertility obtained in May-June, 1977 would suggest again the low sexual activity of ewes in this season. If crossbred rams were therefore more aggressive in the breeding pastures than purebred rams, crossbred rams might stimulate ewes to allow more matings resulting in more ewes conceiving thus the crossbred ram advantage in May-June mating. A similar crossbred ram advantage was obtained in May-June 1974 and 1975 matings. In two years' May-June matings, crossbred rams sired an average of 19 more lambs per 100 ewes exposed. In 1977 May-June mating the advantage was 33 more lambs per 100 ewes exposed.

These and past results suggest the use of crossbred rams when mating in May-June. All of our comparisons of purebred with crossbred rams have involved late spring breeding with yearling rams and we do not know what the results would have been with older rams.

Future Plans

Further evaluation of pure and crossbred rams will continue on the accelerated lambing program. The ewes will be bred to lamb three more times in the next two years.

DAIRY NUTRITION and MANAGEMENT

Profile of DHI Management Factors of Twenty High and Low Producing Holstein Herds

J. D. Stout

Story in Brief

The DHI records of forty Holstein herds were studied to compare the apparent importance of various management factors on herd production. The forty herds represented the twenty highest and twenty lowest producing Holstein herds based on the rolling herd average milk production for the testing year May 1, 1976 to April 30, 1977. Data from the September 1977 Herd Ranking and Summary was utilized for the breeding and genetic information. The twenty high producing herds averaged 18189 lb of milk, 662 lb of fat, while the twenty low producing herds averaged 10257 lb of milk, 366 lb of fat. Both high and low groups differ considerably from the state average of 14308 lb milk, 512 lb fat for all Oklahoma Holsteins in DHI.

The genetic difference between the two groups according to identified sires PD is +289 lb. In the high herds, 76 percent of sires were identified and had a predicted difference for milk (PDM) of +231 lb. In the low herds only 7 percent of the sires were identified and these had a PDM of −58 lb. This low percentage of identified sires and low sire average was apparently due to low herd owners using home raised bulls extensively. Low producing herds culled 15 percent annually while high herds culled 33 percent annually. The top producing herds were apparently fed a higher grain to forage ratio ration than the low group. The high producing herds averaged 1517 lb more concentrates per year than the low herds. Forage feeding averaged 2.2 lb/cwt body weight for high producers compared to 2.5 lb/cwt for the low group. High producing herds had 86 percent days in milk compared to 77 percent days in milk for low producers.

Introduction

Dairymen continue to ask, "What is the difference between the high producing herd and mine?" Factors listed on the various summaries available through the DHI Record Program provide reliable information to answer this question. USDA research (1968) listed pounds of grain fed, percent days in milk and milk price as the primary factors effecting income over feed cost from a dairy herd.

A periodic study of DHI record factors of Oklahoma herds will aid in preparing extension lessons. The objective of this study was to develop apparent profiles of high and low producing herds using all factors available in DHI records. These profiles would be useful in extension education programs in assisting dairymen in achieving more efficient management.

Materials and Methods

Official DHI and DHIR Holstein herds in Oklahoma were ranked by pounds of milk listed on the Rolling Herd Average (RHA) for testing year May 1, 1976 to April 30, 1977. The top twenty herds and low twenty herds having larger than twenty-five cow herd size were selected for this study. The September 1977 Herd Ranking and Summary (HR&S) for the same herds were used for calving interval and genetic data. Herd average data on a per cow basis was then weighted for herd size to obtain a true weighted average for approximately 1600 cows of each group.

All factors that routinely appear on the dairymen's monthly DHI Herd Summary and those of the HR&S which measure intervals and genetic values were summarized for this study and are listed in Table 1.

Results and Discussion

Table 1 lists the average of twenty-two DHI management factors weighted for herd size, of the twenty high and low producing Holstein herds. Weighted averages and the range are listed for each factor. There was very little difference in herd size between the two groups. The high producing herds averaged 83 cows ranging from 35 to 231 cows. The low producing herds averaged 89 cows and ranged from 39 to 236 cows. Body weight was in favor of the high producing group by 120 lb. Examination of individual herd reports revealed that the big difference in body weight was due to the size of first lactation cows.

The primary differences between the high and low producing herds were found by analyzing the breeding program factors. The breeding program is divided into two parts, reproductive efficiency and genetic quality of sires used. In both areas there were wide differences between the two groups. Sire average PD and Percent DIM are highly useful indicators of a herds breeding program. The weighted average of sire's PD for high producers was +231 lb milk and +4 lb fat while low producers had −58 lb milk, and −12 lb fat. The low twenty herds had only 7 percent of the sires identified compared to 76 percent for the high herds. The small number of identified sires in the low

Table 1. DHI management factors for high and low Holstein herds

Management factors from sample day report	High 20 Holstein Herds		Low 20 Holstein Herds	
	Weighted Average	Range	Weighted Average	Range
Herd Size	83	35 to 231	89	39 to 236
Body weight	1310	1110 to 1370	1190	1000 to 1290
RHA milk	18189	17357 to 22328	10257	8614 to 10964
RHA fat	662	594 to 770	366	321 to 430
% Days in milk	86	81 to 93	77	66 to 88
Lbs. concentrate	6243	5400 to 8100	4726	2200 to 6000
Lbs. silage	8867	0 to 14400	5897	0 to 14600
Lbs. hay	4561	0 to 10000	4400	0 to 11200
Pasture days	180	0 to 288	195	0 to 365
Forage feeding rate	2.2	1.7 to 2.7	2.5	1.8 to 3.3
Value of product	$1684	$1457 to $1966	$972	$837 to $1001
Concentrate cost	$401	$219 to $530	$283	$199 to $353
Feed cost	$732	$607 to $941	$550	$429 to $652
Inc/feed cost	$952	$758 to $1352	$421	$236 to $535
Feed cost/cwt milk	$4.23	$2.69 to $5.23	$5.38	$5.02 to 6.92
Factors from Herd Ranking & Summary				
Calving interval	392	368 to 447	387	362 to 457
Lactation length	335	301 to 392	299	272 to 370
Dry period	57	45 to 76	88	65 to 112
% cows with sire ID	76%	0 to 100%	7%	0 to 100%
Sire avg. P.D. milk	+231	−737 to +1113	−58	−2644 to +330
Sire avg. P.D. fat	+4	−29 to +40	−12	−91 to +11
% culling rate	23%	4% to 33%	15%	5% to 27%
Progress in EPA milk	+182	−110 to +474	+59	−116 to +227

herds was due to the use of home raised sires. A survey (Stout, 1976) of all Oklahoma members of AMPI indicated that the lower producing herds were using over 75 percent natural service and purchased more than 50 percent of herd replacements. These data indicate that owners of low producing herds do not consistently use artifical insemination and/or as high genetic caliber sires as do owners of high producing herds.

The range of sires average Predicted Difference (PD) is interesting. The low herd with the high sire PD was also the herd with 100 percent of sires identified but was low in many of the other management factors. The herd with −2644 sire PD was a herd with a considerable number of daughters of one home bred sire. The other sires represented in the cow herd were not identified. The herd in the high group with the −737 lb average sire PD was a small group of purchased highly selected mature cows, the oldest average age of any of the forty herds. The high herd with the high sire average PD of +1113 was also a small group of individually selected cows.

Reproductive efficiency may best be measured by Percent DIM. Percent DIM is the combined function of calving interval, lactation length and length of dry period. A 305 day lactation, 60 day dry period and 365 day calving interval would equate to 83 percent DIM. National statistics (USDA, 1968) indicate that as Percent DIM moves up or down from 83 percent, the rolling herd average changes by 140 lb of milk for each one percent change. When calving intervals are long or when lactations average shorter than normal, the Percent DIM will usually be less than 83 percent. It is recommended that the Percent DIM on the rolling herd average by 84-87 percent. The higher Percent DIM is desired due to two year olds entering the herd without dry days and older cows being sold during lactation. The high producing herds averaged 86 percent DIM compared to 77 percent DIM for the low producing herds, a difference of 9 percent. Calving interval was 392 days for high herds compared to 387 days for the low herds. However, the high herds milked 335 days and dry only 57 days compared to 229 days lactation and 88 days dry for the low group.

Feed data listed in DHI records is an estimation with few dairymen as concerned about accuracy as we would like. Also each farm's feeding program is different based on their forage availability. Considering the information available and average composition for protein and energy, the high producing herds are apparently receiving a much higher level of nutrition. Pounds of milk returned per pound of grain fed is in favor of high producers 2.9 to 2.1. The rate of forage feeding of 2.2 and 2.5 lb/cwt body weight for the high and low groups respectively, indicate that a higher grain to forage ratio is characteristic in high producing herds. High producing herds received over 1500 lb more concentrates per cow than low producing herds. The percentage of total protein and energy requirements for body maintenance and milk production apparently supplied by feeds listed would favor the high producing group. The top twenty herds were fed at approximately 102 percent of calculated needs of both protein and energy, whereas the low producers were fed at approximately 86 percent of protein needs and 108 percent of energy requirements.

The difficulty of comparing feed cost is knowing whether all dairymen use the same basis for determining the value of home grown forages and home mixed grain rations. We suggest that the regular purchasing price be recorded for home grown feeds used. We would have to realize that some fallacy in reported value for these feeds would be in the summaries for both the high and low producing groups; however, the weighted average of \$952 compared to \$421 income over feed cost respectively for high and low groups clearly indicates that the higher production is profitable.

Excellent management is required to maintain high milk production. Attention must be given to sire selection to continually improve the genetic base of herd replacements. Then the feeding and reproductive efficiency must combine to provide the proper environment for the genetic superior animals to express themselves. DHI management factors of the top twenty Holstein herds indicate that those herd owners are providing excellent management. The extra $521 income over feed cost would also suggest that owners of high producing herds were compensated for their efforts.

Literature Cited

USDA, 1968. Dairy Herd Improvement Letter Vol. 44:3

Stout, Jack D. 1976. Ed.D. Thesis, Oklahoma State University, Stillwater, Oklahoma.

Chemical Preservation of Alfalfa Hay for Lactating Dairy Cows

S. A. Jafri, L. J. Bush
and G. D. Adams

Story in Brief

At times it is extremely difficult to harvest alfalfa hay with the high quality desired for high producing dairy cows. In this trial, use of a chemical hay preservative was evaluated as a management technique for minimizing problems encountered in harvesting high quality hay.

Alfalfa hay from a common field was baled as follows: a) dry, at 19 percent moisture, b) wet, at 29 percent moisture, and c) wet, at 28 percent moisture with addition of chemical preservative. The product consisting of 70 percent propionic acid and 30 percent formalin was applied at the rate of 1.0 percent of hay baled.

Heating and molding during storage were prevented by the preservative. *In vitro* digestibility of dry matter in dry baled and treated hay was higher than in hay baled wet with no preservative. In a feeding trial with lactating Holstein cows, treated hay supported milk production equal to that by cows fed dry baled hay. Digestibility of total ration components was similar for dry baled hay and hay treated with chemical preservative. Thus, the commercial hay preservative used in this trial was effective in maintaining hay quality under the conditions described.

Introduction

Alfalfa hay is an important forage to many dairymen in Oklahoma and many other parts of the world. However, weather conditions in Oklahoma sometimes do not permit adequate curing of hay, and leaf shatter in harvesting of field cured hay may result in considerable loss of nutrients.

A relatively new approach to hay harvesting involves addition of a small amount of chemical preservative to the hay at the time of baling. This permits baling at a higher moisture content than is otherwise recommended and in some instances reduces nutrient loss due to shattering of leaves during handling.

Research workers have reported hay quality to be inversely proportional to the moisture content of hay at baling and to temperature attained during storage. High temperature of hay during storage favors a chemical reaction in which hexoses and amino acids react to form indigestible components, thus lowering hay feeding value.

Various chemicals have been tested as possible preservatives for alfalfa hay. Those appearing to be of greatest value at present are ammonium isobutyrate, anhydrous ammonia, propionic acid, and propionic acid combined with formalin. The amount of these chemicals required to prevent heating and molding in baled hay is related to the moisture content of hay at baling. More chemical is required as the moisture content of hay at baling is increased. It appears that application of 1 percent by weight of any of the named chemicals is adequate for preservation of alfalfa with average moisture up to around 30 percent.

No reliable data have been reported on the merits of adding organic acid preservatives to hay at baling for feeding to dairy cows. The purpose of this trial was to evaluate the effect of adding a chemical preservative to hay at baling on its nutrient content, digestibility and feeding value for lactating cows.

Materials and Methods

Mid-bloom alfalfa hay from a common field was baled under three different conditions as follows: a) dry control, baled at an average moisture content of about 19 percent, b) wet control, baled at 29 percent moisture content, and c) preservative treated hay, baled at 28 percent moisture with addition of 1.0 percent commercial hay preservative. This product, containing 70 percent propionic acid and 30 percent formalin, was applied with a positive pressure spray unit as the hay was picked up from the windrow and moved into the baling chamber. The specified amount of preservative was diluted 50:50 with water before application to permit more uniform distribution on the hay. Temperature during the first 3 weeks of storage was monitored by use of thermocouples placed within 30-bale stacks of each type of hay. Readings were recorded twice daily during the first 11 days and daily thereafter.

Sixteen lactating Holstein cows 7-10 weeks post-calving were used in a switchback feeding trial to compare the preservative treated hay with dry baled hay. Comparison periods were five weeks in duration. The experimental ration consisted of a concentrate mixture and alfalfa hay in a 50:50 ratio. Initial feed allowances calculated to meet NRC requirements were based on weight and age of cow, milk yield, and milk fat percentage. These allowances were reduced by 5 percent at the start of 2nd and 3rd periods to minimize weight changes.

Milk production was recorded twice daily with samples from four consecutive milkings each week composited for analysis of fat and total solids percentage. Body weights were recorded on 3 consecutive days at the beginning of the trial and at the end of each comparison period. Digestibility of ration components was determined during the fifth week of each period by using chromic oxide as an indicator.

Digestibility of dry matter in hay baled under the different conditions also was determined by an *in vitro* procedure. Seven designated bales of each type were sampled monthly during the first four months of storage for this analysis.

Results and Discussion

There was no visible mold in the hay treated with commercial preservative or in the dry baled hay, whereas extensive molding was observed in the wet baled hay. The highest average temperature recorded in the stack of wet baled hay was 115 F, in contrast to 94.5 and 98 F in preservative-treated and dry hay stacks (Figure 1).

In the feeding trial, intake of grain and hay was maintained near a 50:50 ratio as planned. Both types of hay were readily accepted by the cows. Average milk yield of cows fed the chemically preserved hay was slightly higher than that of cows fed the control hay; however, there was sufficient variation within treatment groups to cause this difference not to be considered of any real significance. Milk fat and non-fat solids percentages were similar for the two groups (Table 1). The digestibilities of dry matter, neutral detergent fiber (NDF), crude protein, and organic matter were similar for treated and control hays (Table 2). Nevertheless, digestibility values for the rations were in agreement with the production data, indicating that the chemically treated hay was at least equal in quality to the control hay. *In vitro* digestibility of dry matter in dry control hay (19 percent moisture) was only slightly higher than in the chemically treated hay (Table 3). However, *in vitro* digestibility of dry matter in the wet baled hay (29 percent moisture) was considerably lower than in treated hay, indicating the effectiveness of the chemical preservative.

The commercial hay preservative used in this trial was effective in preserving hay quality under the conditions described. However, one should not expect products applied at rates providing less than an effective level of active ingredient to be of any appreciable value in preserving alfalfa hay with 28 to 30 percent moisture content at baling.

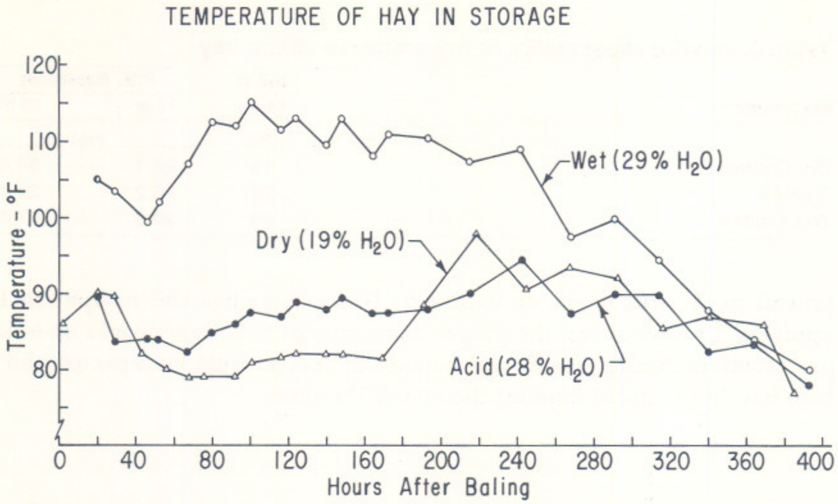

Figure 1. Temperature of hay in 30-bale stacks during storage

Table 1. Responses of cows to experimental rations

	Hay condition at baling	
	Dry (19% H_2O); Control	Wet (28% H_2O); Preservative Added
Feed intake		
Grain, lb/day	21.2	21.3
Hay, lb/day	21.1	21.2
Milk Production		
Yield, lb/day	54.3	55.1
Fat, %	3.68	3.61
NFS, %	8.50	8.62

Table 2. Digestibility of ration components

Component	Hay: Control	Hay: Treated
	%	%
Dry Matter	58.2	60.4
Protein	60.4	62.7
NDF	57.0	57.6
Organic Matter	62.7	63.4

Use of an effective hay preservative can be an economical alternative for minimizing weather risks in harvesting hay. With the recommended application rate, cost of chemicals used in this trial would be around $8.00 per ton of hay baled. In some situations, the benefit gained by using preservatives would more than offset this cost. At other times when favorable weather conditions

Table 3. *In vitro* digestibility of dry matter in alfalfa hay

Hay Treatment	H_2O at Baling	D.M. Digestibility 18 hr	36 hr
	(%)	(%)	
Dry Control	19	26.1	30.4
Treated	28	25.2	29.6
Wet Control	29	20.6	27.4

prevail no benefit could be expected. If a person has the equipment for applying a preservative, the proper management technique would be to use preservatives during periods when some advantage could be expected and to bale hay in the usual manner the rest of the time.

Effect of Prepartum Antibiotic Infusion on Mastitis Infection in Dairy Cows at First Calving

P. B. Barto, L. J. Bush and G. D. Adams

Story in Brief

Mastitis infection continues to be a problem in dairy herds. This report deals with research directed toward prevention of infection in cows at the start of the first lactation.

One-half of a group of heifers was infused with an antibiotic two weeks prior to the aniticipated date of calving. Quarter milk samples for microbiological examination were collected within 8 days after freshening, at 13-16 days and again at 27-30 days.

Two heifers in the antibiotic infused group and 8 of the control group were found to be infected when sampled within the 8 day period after freshening. At the 13-16 day sampling period none of the infused group were infected, but 7 of the control group were infected. At 4 weeks, 2 infused heifers and 3 controls

were infected. There was a significant difference between the two groups of animals in the number of quarters found to be infected at the first two collection periods, but not at the fourth week sampling.

It appears that prepartum antibiotic infusion offers some protection against mastitis infection at calving.

Introduction

Dipping teats of cows with an effective bactericidal solution after each milking and infusing an approved antibiotic into all quarters of the udder at drying off are practices that have reduced the incidence of mastitis infection in dairy herds. In the OSU dairy herd, this program along with culling of chronically infected cows has reduced the infection level to about 5 percent of the quarters.

Very little attention has been given to the incidence of mastitis infection in cows at the time of first calving. It would be logical to expect that the incidence of infection in first lactation animals would be lower than in the total herd, yet this has not been found to be true. In a previous study, once-a-day teat dipping of preparturient heifers beginning about 2 weeks before calving produced no significant reduction in the incidence of mastitis infection at calving (Animal Science Research Report MP-101, 1977).

In the present study, a dry cow antibiotic preparation was infused into the udder of heifers approximately 2 weeks before the anticipated calving date to determine its effect on the incidence of mastitis infection at the time of freshening.

Materials and Methods

By random allotment 68 heifers in the OSU dairy herd were divided into treatment and control groups. Some of these had to be dropped from the experiment for various reasons, leaving 27 treated heifers and 29 controls on which data were obtained. The four breeds in the study were Jersey, Guernsey, Holstein and Ayrshire; however, Holsteins and Ayrshires predominated. All of the heifers were kept in the same pasture prior to calving.

Two weeks before the anticipated date of calving, each of the quarters of heifers in the treatment group were infused with 300 mg of Benzathine Cephapirin, an experimental dry-cow antibiotic preparation by Bristol Laboratories, Syracuse, New York. Skin swabs of a small area of the teat surface of each quarter were collected, and duplicate samples of secretion from each quarter were taken before the anitbiotic was infused. Swabs of the teat skin of comparable animals in the control group were collected on the same day that they were on animals in the treated group, but no quarter secretion samples were taken. The average period of time between infusion of the antibiotic and calving was 18.1 days for the treated group and the time on experiment prior to calving was 18.4 days for the control group. Culture procedures were employed as outlined by the National Mastitis Council.

Table 1. Infection status of heifers at various sampling periods after calving

Sampling Period	Heifers		Quarters	
	Control	Infused	Control	Infused
No. of experimental units	29	27	116	107[a]
No. infected at freshening or at 4-8 days[bc]	8/29[d]	2/25	12/116	2/99[a]
No. infected at 13-16 days[e]	7/27	0/24	7/108	0/96
No. infected at 27-30 days	3/28	2/27	3/112	2/107[a]

[a]One blind quarter.

[b]In the control group, four animals had clinical mastitis at first sampling and three were treated with antibiotics; in the infused group one animal had clinical mastitis and was treated.

[c]Difference between groups of heifers approached statistical significance (P ca .07); difference between groups on quarter basis was statistically significant ($P<.025$).

[d]Numerator denotes number of units infected and denominator denotes total experimental units at specified sampling period.

[e]Difference between groups statistically significant for heifers ($P<.01$) and quarters ($P<.025$).

Duplicate milk samples were collected between 4 to 8 days after calving, or if clinical mastitis was evident, they were collected prior to infusion with an antibiotic. Duplicate milk samples were collected again between 13 to 16 days and at the end of 4 weeks. In a few cases, samples at a particular collection were not valid and are not included in the data. Clinical mastitis cases verified to be caused by infection and sub-clinical infections detected at scheduled sampling periods were counted.

Results and Discussion

The incidence of mastitis at first calving in the control group of heifers was 28 percent. This level of infection also was observed in the control group in a teat-dipping experiment conducted previously and is high enough to be of concern to dairymen. The incidence of infection in the antibiotic infused heifers was only 8 percent (Table 1). Clinical mastitis involved 50 percent of the infected heifers in both groups. By comparison, Sinkevich *et al.*, (1974) noted 25 percent infections were evident as clinical mastitis in cows calving for 2 or more times.

Quarter samples from udders of 28 pregnant heifers cultured prior to infusion of the antibiotic revealed 6 infected animals. Of the 2 heifers in the treated group found to be infected at freshening, one was not infected prior to calving and the other was infected with a different species of bacterium from that found during the pre-parturient sampling. Evidence was obtained that the dry cow antibiotic preparation cleared up infections existing in the pre-parturient period and probably prevented some new infections from developing by the time of freshening.

Of the 2 infected heifers in the infused group one clinical mastitis quarter was treated. This heifer tested negative in the second sampling period but the results were excluded from the data because of the unknown effects of the antibiotic so soon after the treatment. The second heifer recovered spontaneously from the sub-clinical infection without treatement. No new infections developed in this group between the two sampling periods.

Three of the 8 infected heifers in the control group were treated. One heifer was treated in one quarter for clinical mastitis after freshening, but cultures prior to treatment revealed infection in an additional quarter. All quarters were negative on the second sampling. This heifer was excluded from consideration at the next sampling period because of the inability to determine the effect of the antibiotic on the treated as well as the untreated quarter so soon after the treatment. A second heifer was treated in one quarter from which *Staphylococcus epidermidis* was cultured. *Streptococcus dysgalactiae* was isolated from another quarter which was not treated. The infection persisted as a sub-clinical infection through the entire study. This heifer was retained in the experiment. A third heifer was treated in two quarters from which no infectious organisms were isolated. *Escherichia coli* and *Staphylococcus aureus* were isolated from the other two quarters. *E. coli* was not isolated at the 4-8 day sampling; however, *Staph. aureus* was isolated from the same quarter at the 13-16 day sampling. This heifer was also retained in the study. One other control heifer mistakenly not sampled was excluded from the experiment in this sampling period only.

Thus, two heifers showing clinical mastitis soon after freshening which were treated at that time were excluded from the experiment for the 13-16 day sampling period. On the other hand, two others were retained because sub-clinical infections existing during the initial sampling period persisted into the second sampling period.

The lowered incidence of infection in the infused group compared with the controls at the 13-16 day sampling period was significant. The fact that no new infections occurred in the infused group during the first two weeks after calving, whereas 7 infections were present in the control group at the 13-16 day sampling suggests that pre-parturient infusions exerted a protective effect for a period of time after freshening. Perhaps a decreasing concentration but residual antibiotic present in the udder for several days protects the gland from infections during this stress period until its own natural defenses increase in competence.

There was no appreciable difference between the two groups at the 27-30 day sampling, suggesting that the pre-parturient infusion exerts no protective effect after that length of time after freshening. Several of the heifers evidently had recovered spontaneously by this time since the level of infection was relatively low in both groups. However, the fact that approximately 9 percent of the heifers were infected at this point in the lactation means that mastitis infection in first lactation cows is a problem that deserves further attention.

Analysis of the data on the basis of quarters shows that the lowered incidence of infection in the infused quarters compared with the controls was significant for the 8-day period after freshening and for the 13-16 day sampling period. However, the difference between the two groups at the 27-30 day sampling was negligible. The results of the 27-30 day sampling period corresponds with the heifer analysis for the same period.

Literature Cited

Bush, L. J. *et al*. 1977. Ok. Agri. Exp. Sta. MP-101 p. 134.

Sinkevich, M. G. *et al*. 1974. Bovine Practitioner. 9:43.

DAIRY PRODUCTS

Frozen Concentrated Cultures Of *Kluyveromyces fragilis*

M. Bostian and S. E. Gilliland

Story in Brief

Concentrated cultures of *Kluyveromyces fragilis* Y-1156, prepared by suspending the yeast cells in 10 percent nonfat milk solids (NFMS), were frozen at −19 C and −196 C. Cells in concentrated cultures stored at −19 C survived better than those held in liquid nitrogen (−196 C). The age of the yeast culture at the time of freezing affected survival. Cells from the midexponential growth phase survived better at −19 C than those from the stationary phase. The opposite was observed for the yeasts when frozen at −196 C. The highest levels of survival appeared at the midstationary phase. The addition of glucose to the suspending medium, in amounts up to 30 percent, resulted in increased storage stability at both storage temperatures.

Introduction

Research conducted at Oklahoma State University has substantiated that the whey produced as a by-product of the cottage cheese industry can be cultured with the yeast *Kluyveromyces fragilis* and the biochemical oxygen demand (BOD) of the liquid reduced significantly (Knight *et al.*, 1972). In return, a yeast-whey protein material can be recovered which may have some value as a nutritious food supplement for humans and animals alike. Storage of the yeast culture required for this fermentation poses several problems. In the past, large volumes of the yeast-whey mixture have been held back and used as a starter for the next fermentation (Smith *et al.*, 1977). This procedure is troublesome and requires considerable time and storage space. Many times such a procedure results in reduced viability of the yeast culture.

The objective of this study was to find a means of storing yeast culture concentrates in a frozen state, at either −19 C or −196 C, in such a manner that the culture would retain its viability and activity. Storage of such concentrated cultures would require less space and simplify preparation and utilization. Positive results from this experiment could have important applications for other areas of the food industry using yeast cultures in processing.

Experimental Procedure

The medium for growing cells of *K. fragilis* for preparing concentrated cultures was pepsinized whey. It was prepared by dissolving dried Krafen sweet whey (obtained from Kraft Foods Co.) in distilled water (5 g per 100 ml). The reconstituted whey was adjusted to pH 3.0 with 30 percent citric acid and pepsin (25 mg per 100 ml; Sigma Chem. Co.) was added. The mixture was incubated 30 min at 37 C followed by adjusting the pH to 6.5 with 20 percent NaOH. The pepsinized whey was sterilized by autoclaving 15 min at 121 C.

In experiments to determine the effect of cellular age and freezing temperature on survival, four 250-ml Erlenmeyer flasks containing 50 ml of pepsinized whey were placed in a 35 C reciprocating shake water bath (82 strokes of 40 mm per min) and inoculated with 0.5 ml of a *K. fragilis* Y-1156 yeast culture. One flask was removed at 8, 11, 14 and 17 hr. The cells were harvested by centrifugation at 12062 x g for 10 min at 10 C. The cells were resuspended in a total of 5 ml of cold sterile 10 percent nonfat milk solids (NFMS). This suspension was placed in two vials for freezing at −19 C and −196 C. The cultures were plated on Sabouraud Dextrose Agar before freezing and following a three-day storage period. All plates were incubated for 48 hr at 35 C.

Additional experiments were conducted to study the possibility of using glucose as a cryoprotective agent. Ten 250-ml Erlenmeyer flasks, each containing 80 ml of pepsinized whey, were inoculated with 0.8 ml of a *K. fragilis* Y-1156 broth culture. The flasks were incubated 15 hr in a 35 C reciprocating shake water bath as described in the previous paragraph. To prepare the concentrated cultures for freezing, the cells from all 10 flasks were harvested as previously described. The cells were resuspended in a total of 20 ml of cold sterile 10 percent NFMS. Five gram aliquots of this concentrated culture were placed into each of four test tubes, containing 15 ml of 10 percent NFMS and glucose in the amounts of either 0, 2, 4 or 6 grams. This yielded concentrated cultures containing 0, 10, 20 and 30 percent glucose. Four vials (2 g) of each preparation were frozen at −19 C and four at −196 C. One vial of each sample was plated on Sabouraud Dextrose Agar before freezing and after 1, 7, 14 and 21 days storage. All plates were incubated at 35 C for 48 hr.

Results and Discussion

The survival of *K. fragilis* Y-1156 in concentrated cultures during frozen storage varied with physiological age and storage temperature (Table 1). Cultures frozen at −19 C survived much better than did those frozen at −196 C. Greatest survival of cultures frozen at −19 C was observed for those frozen after 8 hr growth. The number of cells surviving freezing after 11 hr growth was somewhat lower than observed for the 8 hr culture. The percentages of survival of the yeast cultures frozen at the 14 and 17 hr growth periods were

Table 1. Effect of cellular age and freezing temperature on survival of *K. fragilis* Y-1156

Growth period (hr)	Initial population/g	% Survival	
		−19 C	−196 C
8	2.0×10^8	80	1
11	6.2×10^8	57	11
14	2.0×10^9	65	12.5
17	1.9×10^9	65	9

Table 2. Effect of glucose concentration, storage time and freezing temperature on survival of *K. fragilis* Y-1156

Glucose concentration (%)	Storage time (days)	% Survival Trial 1		Trial 2	
		−19 C	−196 C	−19 C	−196 C
0	1	90	7.5	85	12
	7	19	5	48	12
	14	49	6	39	10
	21	5	1	32	10
10	1	74	4	98	4
	7	60	5	68	6
	14	79	5	63	4
	21	37	2.5	55	4
20	1	79	8	100	6
	7	66	10	85	6
	14	80	9	85	4
	21	54	8	81	6
30	1	84	96	83	7
	7	69	94	97	8
	14	82	101	83	5
	21	83	100	79	10

slightly higher than at 11 hr but not as high as for the 8 hr cultures. This slight increase may have resulted from higher initial populations for the 14 and 17 hr cultures.

The yeast cultures frozen at −196 C responded in a contrary manner to those frozen at −19 C. There was a negligible amount of survival (1 percent) from cells frozen after an 8 hr incubation. The survival rates seemed to peak between growth times of 11 and 14 hr and decrease again at the 17 hr point.

It appeared from these results that cells of *K. fragilis* grown approximately 14 hr would be most suitable for further freezing trials at both storage temperatures. The use of cryoprotective agents in the suspending media was the next area studied in attempts to increase freezing survival. Glucose was added in various concentrations to concentrated cultures of *K. fragilis* to determine its effect on yeast survival during frozen storage.

The addition of glucose to the suspending medium had no beneficial effect on survival after a one-day storage period at −19 C (Table 2). However, during extended storage (−19 C) periods of 7 to 21 days, the number of yeast cells surviving increased as the amount of glucose in the medium increased.

The concentrated cultures frozen at −196 C again exhibited much lower survival than those frozen at −19 C. Ten and twenty percent glucose provided no protection to cells frozen at −196 C in either trial. At the 30 percent glucose level, however, a discrepancy was observed between the two trials; in trial 1 greater than 90 percent survived at −196 C, while in trial 2 the survival was 10 percent or less. Experimentation is currently being conducted to determine the cause of this difference. It may have resulted from slight differences in the physiological ages of the cultures in the two trials.

It was also observed in this study that damage to the concentrated cultures frozen at −19 C occurred over the total storage period at a slow rate. The damage to yeast cells frozen at −196 C seemed to occur almost immediately, and the viability of these cells changed little during the study period as a whole. The differences in the effect of physiological age of the cells on survival at −19 C and at −196 C suggests that there may be more than one major factor involved in producing cells that will survive freezing during extended storage periods.

Literature Cited

Knight, S., W. Smith and J. B. Mickle. 1972. Cheese whey disposal using *Saccharomyces fragilis* yeast. Cult. Dairy Prod. J. 7:17.

Smith, W., M. Lane and G. F. Stewart. 1977. Pilot plant studies on the reduction of chemical oxygen demand of cottage cheese whey by *Kluyveromyces fragilis*. Okla. Agr. Exp. Sta. MP-101:176.

POULTRY NUTRITION

Efficiency of Utilization of Dietary Phosphorus By Caged Turkey Breeder Hens When Fed Rations Supplemented With Live Yeast Culture

R.H. Thayer, R.F. Burkitt, R.D. Morrison and E. E. Murray

Story in Brief

A sixteen-week feeding trial was conducted with turkey breeder hens maintained in individual laying cages to determine the effect that live yeast culture had on the utilization of both available and total dietary phosphorus. Criteria used to measure the efficiency with which the dietary phosphorus was utilized included level of egg production, egg weight, egg specific gravity, body weight change, feed intake and reproductive performance. The sixteen experimental rations which were used contained two dietary calcium levels and four dietary phosphorus levels within each calcium level, with each calcium-phosphorus combination being fed with and without the addition of live yeast culture. Measurements were made during the course of, and at the end of consecutive four-week intervals as the sixteen-week feeding trial progressed.

The data obtained indicate that a dietary calcium level of 2.25 percent was required for a maximum response in terms of level of egg production, egg weight and egg specific gravity. The addition of live yeast culture to the breeder ration brought about an increase in egg production, egg weight and egg specific gravity, particularly at the two lower dietary phosphorus levels (available phosphorus 0.23 percent/total phosphorus 0.48 percent; and available phosphorus 0.13 percent/total phosphorus 0.36 percent). These two dietary phosphorus levels are well below those recommended for use in commercial turkey breeder rations from the standpoint of available phosphorus. A near statistically significant difference in feed intake between the breeder hens fed the live yeast culture supplemented rations and the unsupplemented rations, along with statistically significant increases in both phosphorus and calcium intake, indicate that an increased intake of calcium and phosphorus was responsible in part for these differences. However, it must be pointed out that the phytase action of the live yeast culture, as previously reported, probably converted at least a part of the phytin phosphorus to

phosphate and substantially increased the level of dietary available phosphorus. Apparently there were no differences in body weight change or reproductive performance, as measured by percent hatch of fertile eggs, among the turkeys fed the four dietary phosphorus levels.

The overall results indicate that the efficiency with which dietary phosphorus was utilized by turkey breeder hens was significantly increased by the addition of live yeast culture to the ration. Supplementation of commercial turkey breeder rations with live yeast culture could bring about a reduction in ration cost by decreasing the amount of relatively high-cost phosphorus supplement that is currently required.

Introduction

Research with broilers at the Oklahoma Agricultural Experiment Station has shown that the phytase activity in live yeast culture significantly increases the efficiency with which dietary phosphorus is utilized. This increase in efficiency of utilization is due to the fact that the phytin phosphorus in the feed ingredients of plant origin is converted by the action of the phytase to phosphate which can be readily absorbed and utilized. This action significantly increases the amount of available dietary phosphorus, and an equal amount of available phosphorus in the form of inorganic phosphorus supplements can be eliminated from the ration. This reduction in the amount of relatively high-cost phosphorus supplements becomes a significant factor in reducing overall ration cost.

A similar situation would exist insofar as the cost of turkey breeder rations is concerned provided the live yeast culture brings about an increase in the efficiency of phosphorus utilization in the same way as it was observed to do with broilers. The feeding trial reported in this paper was designed to determine if the addition of live yeast culture to a breeder ration fed to turkey breeder hens maintained in individual cages would increase the efficiency with which dietary phosphorus was utilized. In addition, some attention was directed toward dietary calcium level in order to determine if the dietary level of calcium could be substantially reduced in line with the reduction in total dietary phosphorus.

Material and Methods

One hundred forty-four turkey breeder hens which were 34 weeks of age were housed in individual laying cages. The laying cages were arranged in eight blocks with sixteen cages per block. The sixteen experimental rations which were fed were distributed at random among the sixteen turkey breeder hens within each block. This arrangement provided eight individually-fed breeder hens per experimental ration. In addition, it was possible to estimate variation in treatment response due to position within the house itself. Each individual laying cage was equipped with a feeder, an automatic water fountain and a feed container.

The sixteen experimental rations were formulated to contain dietary nutrient levels equivalent to those recommended for use under commercial production conditions with these nutrients being provided in the form of feed ingredients commonly used in commercial rations. The basal ration presented in Table 1 was modified to provide the dietary levels of calcium, phosphorus and live yeast culture as described in the discussion which follows.

Deviations from standard recommendations were made for both calcium and phosphorus. Dietary calcium levels of 2.25 and 1.5 percent were used. The dietary calcium level of 2.25 percent is the dietary level recommended for use under commercial production conditions. The dietary level of 1.5 percent represents a reduction in total dietary calcium level. This reduced dietary calcium level was included in order to provide a number of different calcium to phosphorus ratios and to determine if dietary calcium requirements would be altered in anyway under the conditions of this feeding trial.

Four dietary phosphorus levels were included. These were: available phosphorus 0.45 percent with a total phosphorus level of 0.70 percent (standard recommendation); available phosphorus 0.34 percent with a total phosphorus level of 0.59 percent; available phosphorus 0.23 percent with a total phosphorus level of 0.48 percent; and available phosphorus 0.13 percent with a total phosphorus level of 0.36 percent. These four dietary phosphorus levels were used in combination with each of the two dietary calcium levels which were previously described. The eight experimental rations formulated in this way were fed both with and without the addition of 2.5 percent of live yeast culture. Supplementation of these eight experimental rations with live yeast culture increased the total number of experimental rations to sixteen.

The sixteen experimental rations were fed to the turkey breeder hens during a feeding period of sixteen weeks. The overall feeding period was divided into four time intervals (periods) with four weeks in each period. Data were collected during or at the end of each four-week period and a statistical analysis of these data was made on a period by period basis. Measurements which were taken included feed consumption from which calcium and phosphorus consumption were calculated, body weight, egg production, egg weight, egg specific gravity and reproductive performance in terms of hatchability.

Results and Discussion

Egg production data expressed in percent by periods is presented in Table 2. There were no statistically significant differences at the 5 percent level of probability in percent egg production due to dietary phosphorus level, dietary calcium level or live yeast culture supplementation within any given period. However, there was a live yeast culture × calcium level interaction in Period 1 ($P<.16$) and Period 2 ($P<.08$); and in Period 3 the increase in egg production which was brought about by the addition of the live yeast culture was statistically significant at the 10 percent level of probability.

Table 1. Basal ration used in formulating the sixteen experimental rations

Ingredients	Percent
Tallow, feed grade	5.12
Yellow corn, ground	58.81
Soybean oil meal (44%)	23.55
Meat and bone scrap (50%)	1.67
Blood meal (80%)	1.71
Dried whey (12%)	0.68
Alfalfa meal (17%)	0.68
dl Methionine	0.11
Vitamin mix[1]	0.25
Phosphorus supplement (Ca 22%, P 18%)	1.79
Calcium carbonate	5.07
Trace mineral mix[2]	0.06
Salt	0.50

[1]Contain per pound of vitamin mix: Vitamin A 1,600,000 IU; Vitamin D_3 600,000 IU; Vitamin E 5400 IU; Menadione Sodium Sulfite Complex 400 mg; Riboflavin 1,000 mg; Niacin 3,000 mg; d-Pantothenic Acid 3,200 mg; Choline 80,000 mg; Thiamin 400 mg; Pyridoxine 400 mg; Vitamin B_{12} 1.6 mg; d-Biotin 20 mg; and Folic Acid 200 mg.

[2]Provides in the ration: Manganese 120 ppm; Zinc 80 ppm; Iron 60 ppm; Copper 10 ppm and Iodine 1.0 ppm.

Nevertheless, there were a number of real differences in percent egg production that were consistent throughout the experiment. There was some tendency for egg production to drop off as dietary phosphorus level decreased when no live yeast culture was fed. The addition of live yeast culture increased egg production at all dietary phosphorus levels, but this increase was particularly apparent at the two lower dietary phosphorus levels. The same trend was observed with both dietary calcium levels.

Thus it can be concluded that there was a substantial increase in egg production which was brought about by the addition of live yeast culture to the breeder ration. This increase was most pronounced at dietary phosphorus levels below the dietary levels recommended for use in commercial breeder rations. These data give a strong indication also that the live yeast culture is responsible for an increase in the efficiency with which nutrients other than phosphorus are being utilized. This is based upon the fact that the increase in efficiency of utilization (as measured by level of egg production) is evident even though recommended dietary levels for all nutrients are being fully met.

The egg specific gravity data and egg weight data are summarized in Table 3. There were a number of relationships among dietary calcium level, dietary phosphorus level and live yeast culture supplementation which provide evidence that these three factors were closely related to shell strength, as measured by egg specific gravity and egg weight. There was a live yeast culture × dietary calcium level interaction related to egg specific gravity in Period 2 ($P<.13$), and a dietary calcium level × dietary phosphorus level interaction in Period 3 ($P<.05$). A dietary calcium level of 2.25 percent produced an average egg specific gravity class value of 4.85 as compared to 4.46 for the dietary calcium level of 1.5 percent in Period 1 ($P<.01$), and average class values of

Table 2. Egg production data by periods in percent

	Calcium level 2.25%							
	Period 1		Period 2		Period 3		Period 4	
Phosphorus level (percent)	No LYC[1]	LYC	No LYC	LYC	No LYC	LYC	No LYC	LYC
Available 0.45/total 0.70	62.9	65.6	54.9	56.7	45.5	46.9	28.1	40.6
Available 0.34/total 0.59	62.9	62.1	50.9	56.3	41.5	52.7	42.9	47.8
Available 0.23/total 0.48	61.6	64.3	51.3	66.5	40.6	46.9	39.3	43.3
Available 0.13/total 0.36	59.4	70.1	52.2	60.7	45.5	54.9	50.9	43.8
	Calcium level 1.50%							
	Period 1		Period 2		Period 3		Period 4	
Phosphorus level (percent)	No LYC	LYC	No LYC	LYC	No LYC	LYC	No LYC	LYC
Available 0.45/total 0.70	68.8	59.8	61.2	55.8	49.6	50.4	40.6	56.3
Available 0.34/total 0.59	64.3	63.4	55.8	65.2	34.8	43.8	41.1	46.9
Available 0.23/total 0.48	62.1	62.5	60.7	55.4	52.7	52.7	64.7	48.2
Available 0.13/total 0.36	57.6	60.3	58.0	50.9	39.7	48.7	42.0	46.9

[1]Live Yeast Culture.

Table 3. Specific gravity and egg weight data

Phosphorus level (percent)	Sp. gr.[2]	Egg wt.	Sp. gr.	Egg wt.	Sp. gr.	Egg wt.	Sp. gr.
Calcium level 2.25%							
	Period 1				**Period 2**		
	NQO LYC[1]		LYC		No LYC		LYC
		(g)		(g)		(g)	
Available 0.45/total 0.70	5.11	87.3	4.98	83.7	3.53	82.6	4.44
Available 0.34/total 0.59	5.20	84.0	4.89	84.6	4.22	86.7	4.74
Available 0.23/total 0.48	4.68	83.1	4.84	83.9	3.61	77.4	3.96
Available 0.13/total 0.36	4.97	80.9	4.17	86.0	3.71	76.4	4.06
	Period 3				**Period 4**		
Available 0.45/total 0.70	3.10	80.9	3.36	78.3	1.75	57.4	2.50
Available 0.34/total 0.59	4.25	78.7	4.31	89.9	3.91	66.7	2.89
Available 0.23/total 0.48	3.08	79.2	3.70	75.6	2.95	54.8	2.66
Available 0.13/total 0.36	3.98	90.4	3.51	90.4	2.74	65.9	2.58
Calcium level 1.50%							
	Period 1				**Period 2**		
	NO LYC		LYC		No LYC		LYC
		(g)		(g)		(g)	(g)
Available 0.45/total 0.70	4.16	83.6	4.34	83.3	4.04	87.1	3.98
Available 0.34/total 0.59	4.71	83.0	4.45	84.1	4.02	86.1	3.52
Available 0.23/total 0.48	4.65	83.6	4.29	82.2	4.24	85.9	3.35
Available 0.13/total 0.36	4.27	81.3	4.81	82.0	3.25	75.6	4.03
	Period 3				**Period 4**		
Available 0.45/total 0.70	3.48	79.0	3.58	76.0	1.98	43.6	3.29
Avialable 0.34/total 0.59	3.23	64.6	3.00	82.6	2.23	66.6	2.81
Available 0.23/total 0.48	3.67	88.4	3.97	85.5	3.19	87.8	2.33
Available 0.13/total 0.36	2.38	76.5	3.23	75.4	2.73	57.0	3.14

[1]Live Yeast Culture.

[2]Specific gravity expressed as follows: 1= 1.070, 2= 1.075, 3 =1.080, 4 = 1.085, 5 =1.090, 6 = 1.095, and 100.

Table 4. Phosphorus and calcium consumption data

Calcium level 2.25%

Phosphorus level (percent)	Period 1 P consumption[1] No LYC[3] T[4]	Period 1 P consumption[1] No LYC[3] A[5]	Period 1 P consumption[1] LYC T	Period 1 P consumption[1] LYC A	Period 1 Ca consumption[2] No LYC	Period 1 Ca consumption[2] LYC	Period 2 P consumption No LYC T	Period 2 P consumption No LYC A	Period 2 P consumption LYC T	Period 2 P consumption LYC A	Period 2 Ca consumption No LYC	Period 2 Ca consumption LYC
Available 0.45/total 0.70	35.7	23.0	36.3	23.5	114.9	115.1	32.6	21.0	38.4	24.9	104.9	121.6
Available 0.34/total 0.59	29.4	16.9	31.6	18.4	112.1	118.5	28.2	16.2	34.0	19.9	107.4	127.7
Available 0.23/total 0.48	24.7	11.8	27.4	13.7	115.6	123.1	26.6	12.7	29.0	14.5	124.5	130.4
Available 0.13/total 0.36	17.5	6.3	20.4	7.3	109.3	117.6	20.5	7.4	22.2	8.0	128.1	128.2
	Period 3						**Period 4**					
Available 0.45/total 0.70	35.3	22.7	38.3	24.8	113.6	121.4	34.7	22.3	39.2	25.4	111.7	124.2
Available 0.34/total 0.59	30.7	17.7	35.3	20.6	117.0	132.6	34.6	19.9	29.8	17.4	131.9	111.7
Available 0.23/total 0.48	27.2	13.1	27.8	13.9	127.7	125.2	24.2	11.6	31.9	15.9	113.3	143.5
Available 0.13/total 0.36	21.7	7.8	21.0	7.5	135.4	121.2	15.1	5.4	23.4	8.4	94.1	135.0

Calcium level 1.50%

Phosphorus level (percent)	Period 1 P consumption No LYC T	Period 1 P consumption No LYC A	Period 1 P consumption LYC T	Period 1 P consumption LYC A	Period 1 Ca consumption No LYC	Period 1 Ca consumption LYC	Period 2 P consumption No LYC T	Period 2 P consumption No LYC A	Period 2 P consumption LYC T	Period 2 P consumption LYC A	Period 2 Ca consumption No LYC	Period 2 Ca consumption LYC
Available 0.45/total 0.70	35.6	22.9	38.2	24.4	76.3	79.5	37.3	24.0	38.4	24.5	80.0	79.9
Available 0.34/total 0.59	29.8	16.9	32.5	18.7	74.4	80.0	31.1	17.6	35.0	20.1	77.7	86.0
Available 0.23/total 0.48	23.8	11.2	23.0	11.5	72.8	69.1	25.4	11.9	25.7	12.8	77.6	77.0
Available 0.13/total 0.36	17.9	6.1	20.2	7.1	70.7	75.8	19.4	6.6	21.2	7.4	76.4	79.4
	Period 3						**Period 4**					
Available 0.45/total 0.70	39.7	25.5	39.5	25.2	85.0	82.3	44.1	28.4	38.8	24.8	94.6	80.8
Available 0.34/total 0.59	30.9	17.5	34.8	20.0	77.3	85.5	31.6	17.9	32.5	18.7	79.0	80.0
Available 0.23/total 0.48	27.5	12.9	27.8	13.9	84.3	83.5	27.4	12.9	24.7	12.4	84.0	74.2
Available 0.13/total 0.36	19.0	6.5	20.8	7.3	74.9	77.9	19.6	6.7	24.4	8.5	77.6	91.5

[1] Phosphorus consumption in grams per hen per 28 day period.
[2] Calcium consumption in grams per hen per 28 day period.
[3] Live Yeast Culture.
[4] T = total phosphorus.
[5] A = available phosphorus.

3.66 and 3.32 for these two dietary calcium levels, respectively, in Period 3 ($P<.17$). A somewhat similar situation was observed insofar as egg weight was concerned. Breeder hens fed a ration which contained a dietary calcium level of 2.25 percent laid eggs which weighed 84.2 grams as compared to 82.9 grams for breeder hens fed the ration with a dietary calcium level of 1.5 percent. In addition, there was a live yeast culture × dietary calcium level interaction in Period 2 ($P<.11$).

A comparison of the egg specific gravity data and egg weight data in Table 3 in terms of live yeast culture supplementation indicates that the values for both of these measurements tend to be higher when live yeast culture is fed. The greatest differences in these values were evident with those rations which contained the two lower dietary phosphorus levels. A similar observation relating to dietary phosphorus level has been discussed previously in this paper insofar as egg production was concerned.

Thus it would appear that a dietary calcium level of 2.25 percent more nearly meets the calcium intake requirements than does a dietary calcium level of 1.5 percent. Again, as had been the case with egg production, there was a real advantage to be gained by supplementing the breeder ration with live yeast culture.

Some idea as to what was happening can be obtained from the calcium and phosphorus consumption data which are summarized in Table 4. Feed consumption figures are not presented, but there was an increase in feed consumption when live yeast culture was fed in Period 1 ($P<.11$) and Period 2 ($P<.13$). This increase in feed consumption when live yeast culture was fed resulted in a statistically significant increase in both calcium and phosphorus intake as follows: Period 1 - calcium $P<.06$, phosphorus $P<.01$; Period 2 - calcium $P<.06$, phosphorus $P<.01$; and Period 3 - phosphorus $P<.06$. However, the increase in feed consumption and the increase in the intake of available phosphorus (dietary level of available phosphorus prior to consumption) would not provide an adequate amount of available phosphorus for absorption from the intestinal tract. Since the two lower dietary phosphorus levels appeared to be equivalent to the two higher dietary phosphorus levels when live yeast culture was fed, a significant amount of the phytin phosphorus must have been converted to phosphate through the action of the phytase in the live yeast culture. This action appeared to have been complemented also by the overall effect of the live yeast culture in bringing about an increase in the efficiency with which all nutrients were utilized.

Data on body weight change and reproductive performance are not reported. However, under the conditions of this experiment there appeared to be no significant effect of treatment on these two measurements.

Based upon these data it would appear that ration cost can be reduced through the use of live yeast culture in those situations where all dietary nutrient levels are near marginal or where the amount of phosphorus supplement needs to be reduced because supplies are relatively unavailable and expensive. Cost comparisons would need to be made in each specific case in order to determine if a real saving could be made.

MEAT and CARCASS EVALUATION

A Review of Trends in Ground Beef Production

P. A. Will and R. L. Henrickson

Story in Brief

If the beef industry had to pick a single product to best meet today's market need, that product would be ground beef. The American Meat Institute estimated that in 1975 the American public consumed 50 billion hamburgers. In 1970, ground beef of all types represented one-fifth (20 percent) of all beef consumed in the United States. Today, ground beef consumption represents twice that amount (40 percent) of all beef consumed in the U.S. Estimates from various sources indicate that by 1982 the consumption of ground beef will be more than half (50 to 60 percent) of all beef supply. When one considers that the majority of the U.S. population is less than 25 years old, there is little doubt that a "Hamburger Society" has been created.

Introduction

Until recently, ground beef was mainly considered a method to utilize trimmings and less tender cuts. But while the industry considered ground beef as a poor cousin to steak and roast, the consumer considered ground beef as an excellent product to meet its needs.

The trend today is clearly toward everyday low prices for ground beef and high prices for the so-called "better" cuts of beef. The average retail price of all beef in the United States during 1976 was about 85¢ per pound, compared to an average of $1.86 for the "better" cuts.

Material

Hamburger, ground beef or chopped beef can be defined in a legal manner as chopped fresh and/or frozen beef with or without the addition of beef fat and/or seasoning. It shall not contain more than a total of 30 percent fat.

Acceptable seasonings include salt, sweetening agents, flavorings, spices, monosodium glutamate and hydrolyzed vegetable protein, provided they are added in condimental proportions. Paprika and other substances which might influence the coloration of the product are not included in the acceptable seasoning category. No water may be added, and no tongue, heart, weasand, or kidney is permitted (Encyclo. of label. Meat & Poultry Prod.).

Results and Discussion

Nutritionally, ground beef is on a par with any other beef cut. Meat processors are constantly attempting to look at new alternatives to produce a cooked product with excellent aroma, flavor, tenderness and juiciness. One recent technical advance has been flake cutting of meat. Conventional plate grinders squeeze and extrude meat through perforated plates. On the other hand, flake cutting has a stationary cutting head made up of a continuous ring of cutting surfaces. Meat is forced across the cutting edges by high speed impeller, producing thin uniformly cut flakes of meat without being crushed. The advantages claimed for flake cutting include improved texture, retention of natural juices (less drip loss), better binding and cohesive properties, reduced cooking loss, improved sensory characteristics and elimination of gristle and connective tissue (Fenen, 1972). Research conducted by Randall and Lammond (1977) using boneless beef rounds and beef kidney fat compared flake-cutting and grinding for acceptability and quality for hamburger patties with 15 percent fat. Preweighed frozen patties were allowed to drip freely on filter paper pads at room temperature for 3 hours reaching a surface temperature of 18.5 C. After determining "thaw-drip" patties were held overnight at 3 C. and reweighed to determine the "total-drip". Table 1 shows the drip losses obtained for grinding vs flake cut (FC) hamburger. The drip losses obtained for "thaw-drip" were less than 1 percent. The "total-drip" losses for both types of patties were less than 4 percent with the FC patties having significantly less drip. These results indicated that the moisture and juices were tightly bound in both types of patties and more so in those comminuted by flake cutting. Cooking loss was similar, 26 and 25 percent for both patties types whether prepared by grinding or flake cutting.

A trained panel analyzed both types of patties for appearance, flavor, doneness, texture, tenderness, chewiness, juiciness and greasiness (Table 2). The trained panel found no significant differences in appearance, flavor or doneness between cooked patties prepared by the two methods. They did find, however, that the patties differed significantly in all other characteristics. The ground meat had a finer texture whereas the flake-cut meat was coarser. The ground meat was more tender, less rubbery, more juicy and more greasy than the flake-cut meat. Previous studies showed that flake-cut meat had improved binding and cohesive properties which may explain why the panelists found flake-cut patties to have a coarser grind (texture).

Table 1. Effect of flake cutting and grinding on drip and cooking losses in 15 percent fat hamburger patties

Type of Patty	Thaw Drip[a] (%)	Total Drip[a] (%)	Cooking Loss[a] (%)
Flake-cut	0.88±0.23a	2.35±0.45a	25.02±0.62a
Ground	0.90±0.24a	3.34±0.49b	26.03±0.64a

[a]Mean – Std dev for 10 patties/trt. Values in each column followed by same letter are not significantly different ($P<0.05$).
Randall & Larmond, 1977, J. Food Sci., Vol. 42. p. 728.

Table 2. Mean values[a] for characteristics evaluated by trained panel

	Ground Patties[b]	Flaked Patties	SE
Appearance	4.5a	4.5a	0.14
Flavor	3.2a	3.2a	0.11
Doneness	4.1a	4.3a	0.08
Texture	2.4b	3.7a	0.28
Tenderness	4.3a	2.8b	0.24
Chewiness	2.6b	4.0a	0.21
Juiciness	3.9a	2.7b	0.19
Greasiness	3.1a	2.3b	0.15

[a]Each value is the mean of 80 observations on the scale 0-6.0.
Higher value denotes greater intensity of the characteristic.
[b]Any two values in a line not followed by the same letter are significantly different at the 5% level.
Randall & Larmond, 1977, J. Food Sci., Vol. 42. p. 728.

Improved binding and cohesive properties could also account for the reduced tenderness and juiciness, increased chewiness and reduced greasiness of flake-cut patties. The results of this study indicated that some of the desirable charateristics, primarily those related to textural properties, produced by flake cutting contributed to a steak-like product which is not required in a beef patty. When patties are produced from flake-cut meat, close control of meat temperature, blade speed, and duration of blending are all important in controlling cohesion properties of the beef pattie.

Two additional trends in hamburger processing are worthy of note. These are the use of vegetable proteins as fresh meat extender and the pre-cooking, freezing, and reheating of ground beef patties. Bowers & Engler (1975) studied the effect of pre-cooking, frozen storage and reheating on eating quality, cooking loss, percentage of moisture and TBA Value (level of rancidity) of ground beef and beef-soy blends (15 and 30 percent soy). Table 3 shows that losses (including initial cooking and reheating) were affected signigicantly by both percentage of textured soy added and the heating treatment. Adding textured soy protein to ground beef decreased the cooking loss. It generally is thought that soy additives bind some of the moisture during the heating process causing the cooking loss to be reduced.

The percentage moisture (Table 3) was significantly less in the pure beef patties than in beef soy blend patties. Neither the amount of rehydrated soy added (15 or 30 percent) nor the reheating process affected moisture content.

Table 3. Means of cooking loss, chemical measurements of freshly cooled and cooked-reheated beef and beef-soy patties

Factor	Freshly Cooked			Cooked-reheated		
	0%Soy	15%Soy	30%Soy	0%Soy	15%Soy	30%Soy
Total cooking loss (Cooking × reheating)%	33.95a	29.94b	26.05c	43.06d	37.56e	31.33f
Total moisture	52.23a	54.93b	55.53b	50.50a	54.02b	55.81b
TBA value	0.371a	0.171b	0.141b	0.346a	0.119b	0.110b

[a]Change in letter represents statistical significance ($P<0.01$)
Bowers & Engler (1975), J. Food Sci., Vol. 40, p.624.

Table 4. Sensory evaluations of freshly cooked and cooked-reheated beef and beef soy patties

Factor	Freshly Cooked			Cooked-reheated		
	0%Soy	15%Soy	30%Soy	0%Soy	15%Soy	30%Soy
Sensory Evaluations						
Meaty:						
Aroma	4.0*	2.0b	1.5b	1.8b*	2.8b	1.4b
Flavor	5.0a**	2.4b	1.4b	3.5b**	2.4b	1.6b
Stale						
Aroma	2.2a	1.6a	1.6a	3.6b*	1.7a	1.9a
Flavor	1.6a	1.6a	1.6a	4.0b**	1.7a	1.6a
Cereal-like						
Aroma	1.4	4.4	4.9	1.0	4.5	5.4
Flavor	1.3	4.1	5.3	1.1	4.0	5.2
Juiciness	4.8a**	4.2a	4.1a	3.4b	3.8b	3.4b
Texture	3.5a**	4.5b	4.8b	4.0b	4.0b	4.6b
Overall acceptability	5.1a	3.4b	2.9b	3.6b	3.6b	2.6b

Intensity scale of 1 - 7
*$P<0.05$
**$P<0.01$
Bowers & Engler, 1975, J. Food Sci. Vol. 40. p. 624.

TBA Values determined as an indicator of oxidative rancidity showed that heating had no effect. However, beef-soy blends (15 or 30 percent) had significant but lower TBA Values than pure beef. The differences may be due to the antioxidant effect of soy or from less fat in the soy beef blend.

Sensory work provided in Table 4 showed that meaty aroma and flavor of freshly cooked beef patties was scored higher than reheated and freshly cooked beef-soy patties. Generally, meaty flavor and aroma decreased with increased soy. After frozen storage and reheating, beef and beef-soy blends differed less in meaty flavor and aroma than when patties were freshly cooked.

Stale flavor and aroma (Table 4) of reheated beef patties were greater than for the freshly cooked patties. Taste panel scores given to the freshly cooked patties indicated that practically no stale flavor or aroma was present.

Cereal-like flavor and aroma was more detectable as the amount of soy increased. Heating the ground beef had no effect on cereal-like flavor or aroma. Even though soy-beef blends contained more moisture than pure beef, adding soy did not affect juiciness. However, reheated patties were less juicy than freshly cooked patties. Based on overall acceptability, freshly cooked beef was more acceptable than any other product tested. As the level of soy increased, the less acceptable were freshly cooked reheated patties. However, the difference was significant in acceptability between reheated beef only when 30 percent soy was added. There was no significant difference in acceptability between reheated beef and freshly cooked beef-soy patties with either 15 or 30 percent soy.

The effects of cooking and heating on the fatty acid composition of foods have been reported by Janicki and Appledorf (1974). The increasing consumption of fast foods and the interest in lipids and their relationship to health justify a closer look at the lipid composition of franchise fast foods. The two most popular cooking methods used by hamburger franchises are broiling and grill frying. Microwave ovens are gaining in popularity in large scale feeding operations to reheat conventionally prepared foods and to thaw and warm precooked frozen foods (Keefe and Goldblith, 1973). The objectives of their study were to compare moisture, crude fat, cholesterol, and total fatty acid patterns of ground beef before and after cooking. In addition, the effect of microwave reheating of prebroiled, frozen ground beef patties was determined.

Heating methods and cooking periods used as treatments for the ground beef patties are shown in Table 5. No statistical differences in mean weights and percent yield were found between broiled and grill fried patties (Table 6). Raw beef patties cooked in a microwave oven showed lower weight, percentage yield, and weight of moisture than the broiled and grill fried patties. Meat patties that had been precooked by broiling, frozen, and then reheated in the microwave oven, weighed the least when compared to all other cooking procedures studied, thus having correspondingly the lowest percentage yield and moisture content. This lower yield would be expected since the patties in effect underwent two heating processes.

Mean values and standard deviations for the weight of crude fat and total cholesterol are given in Table 7. Method of cookery affected the fat content remaining in the cooked patties. The mean crude fat content was similar between the broiled and the grill fried beef patties and also between the broiled and the microwave reheated patties. The microwave cooked patties showed the greatest loss of crude fat. Decreases in the total cholesterol content were observed in all cooking treatments except the microwave oven when compared to the raw patties. The decrease, however, was not significantly different among cooking treatments.

The mean values for the fatty acids obtained from the ground beef patties for each treatment are presented in Table 8. Significant percent composition changes occurred in the C16, C18:1, and C18:2 fatty acids for all methods of cooking. The C16 fatty acid (palmitic) underwent the greatest percent loss

Table 5. Heating treatments and cooking times

Treatments	Cooking time
Raw	
Broiled	50 sec.
Grill frying	4 min.
Microwave	90 sec.[a]
Broiled-frozen-microwave	75 sec.[b]

[a]Two heating cycles of 45 sec. each.
[b]Two heating cycles 45 and 30 sec. respectively.
This cooking time does not include the broiling, only the microwave heating.
Janicki & Appledorf, 1974, J. Food Sci., Vol. 39, p. 715.

Table 6. Effect of cooking method on percent yield and composition of ground beef patties[a]

Treatment	Weight(gm)	Yield(%)	Moisture(g)
Raw	107.5±2.8a	100a	67.6±2.3a
Broiled	73.1±5.3b	67.4±4.6b	42.5±4.1b
Grill fried	73.3±3.7b	67.8±3.3b	42.4±3.4b
Microwave	64.6±2.5c	59.7±2.4c	36.2±2.2c
Broiled-frozen microwave	59.8±2.6d	55.3±2.6d	30.4±2.9d

[a]Mean ± STD. dev. for 12 patties/trt. Values in each column followed by the same letter are not significantly different (P<0.05).
Janicki & Appledorf, 1974, J. Food Sci., Vol. 39, p. 715.

Table 7. Effect of cooking method on composition of ground beef patties[a]

Treatment	Crude fat (gm)	Total cholesterol(mg)	Cholesterol/crude fat × 10^3
Raw	18.1±2.3a	77±11a	4.47±1.27c
Broiled	10.0±1.0bc	63±12b	6.36±1.37b
Grill fried	10.5±1.2b	62±14b	6.02±1.82b
Microwave	8.0±1.0d	70±17ab	9.03±2.64a
Broiled-frozen microwave	8.9$^+$1.2c	61$^+$11b	6.98±1.71b

[a]Mean ± STD. dev. for 12 patties/treatment. Values in each column followed by the same letter are not significantly different (P<0.05).
Janicki & Appledorf, 1974, J. Food Sci., Vol. 39, p. 715.

during cooking and was further reduced in the microwave reheated broiled, frozen patties. The percent of C18:1 and C18:2 fatty acids increased following all cooking treatments. The C18:1 (Oleic) and C18:2 (Linoleic) fatty acids are probably more intimately involved as structural components of phospolipids and are less likely to be lost as drip.

The ratio of unsaturated to saturated fatty acids increased during all cooking treatments. The microwave treated patties showed the largest ratio of unsaturated to saturated fatty acids.

Table 8. Effect of cooking method on relative percent fatty acid composition of total lipid extract

10	0.1	0.1	0.1	0.1	0.1
12	0.1	0.1	0.1	0.1	0.1
14	2.8	2.8	2.7	2.8	2.8
14:1	1.8	1.5	1.8	1.9	1.6
14:2	0.4	0.4	0.4	0.5	0.6
16	27.1	25.4*	25.9*	25.6*	23.8*
16:1	5.5	5.1	5.8	6.0	5.0
17	1.2	1.3	1.2	1.1	1.2
16:2	0.7	0.8	0.8	0.8	0.7
18	16.4	15.3	14.4	14.4	14.9
18:1	39.5	42.0*	42.0*	41.4*	42.5*
18:2	2.4	3.6*	2.7*	3.1*	4.0*
20	0.2	0.2	0.2	0.2	0.2
18:3	1.2	1.2	1.2	1.2	1.3
22	0.2	0.2	0.2	0.3	0.3
20:4	0.3	0.3	0.4	0.6	0.8
Sat	48.1	45.5	44.8	44.6	43.4
Unsat.	51.8	55.1	55.1	55.5	56.5
Unsat/sat	1.07	1.21*	1.23*	1.24*	1.30*

[a]Number identifies the chain length and number after colon signifies the number of double bonds.
*Significantly different from raw at 0.05 level.

The results of these studies indicated no nutritional advantage in terms of lipid composition between broiled and grilled ground beef patties. Microwave heating, however, produced a pattie with less crude fat than the two conventional cooking methods. However, the brown crust did not occur in patties heated by microwave alone due to the short cooking time and low surface temperature.

Mechanical Tenderization of Electically Stimulated Muscle

M. Raccach and R. L. Henrickson

Story in Brief

Cooking time, cooking loss, tenderness, and microbial counts of electrically stimulated blade tenderized muscles were examined. In most cases, no significant ($P<0.05$) differences were found in cooking time and and cooking loss among tenderized and non-tenderized muscles. However, the blade biceps femoris and semimembranous muscles were significantly ($P<0.05$) more tender than their control. Sanitizing the blading machine with an iodine based compound provided a 100 fold lower Aerobic Plate Count for the interior portion of the tenderized muscle as compared to the muscle surface count. In all instances Total Coliform and Total Enterobacteriaceae were $<1.0\times 10^1$/g of meat.

Introduction

Tenderness is one of the most important quality attributes of meat. A number of procedures have been developed to improve meat tenderness. These procedures include, physical (carcass suspension, mechanical restraint of muscles), environmental (elevated pre rigor temperatures, post rigor aging), enzymatic (tropical plant or fungal enzymes) and electrical stimulation procedures which are all well established.

Recently studies have been conducted on blade tenderization of beef. Davis (1976) demonstrated that blading provided an increase in meat tenderness greater than that achieved by cooler aging. Blade tenderized muscles of beef were more tender than their control as determined by both a sensory panel and shear force values (Campbell, 1976; Glover, 1975), but these samples had a higher cooking loss. Both animal age and nutritional regimen may have an effect on the blade tenderization muscles (Campbell, 1976).

The purpose of this work was to evaluate the effect of blade tenderization of electrically stimulated muscles on the heat transfer, tenderness and microbial quality of the muscles.

Materials and Methods

Beef carcasses

Carcasses from commercial Angus and Hereford steers in the weight range of 271 to 302 Kg were used.

Electrical stimulation

The electrical stimulation (a square wave pulse of 300V, 400 cpm with a duration of 0.5 msec and a current of 1.6 to 1.8 amp) of beef sides started at 30 min post mortem and continued for 15, 5 and 2 min. Both sides, stimulated and non-stimulated, were held at 16 C during the stimulation and up to 1.5 hr post mortem.

Boning

The Semimebranosus (SM), Biceps Femoris (BF) and Longissimus Dorsi (LD), (from the end of the Ilium to the fifth thoracic vertebrae), muscles from the stimulated side were cut in half at the center of their long axis. This group was labeled "hot boned hot". The unstimulated side was stored at 1.1 C for 22-24 hr and served as a control (conventional boning). A portion of each hot boned muscle was chilled for 15 hr and labeled "hot boned chilled" then sampled for the various measurements.

Blade tenderization

One half of each muscle was blade tenderized twice (top and bottom) using a Hollymatic AMT 625A Blade Tenderizer (Hollymatic Corp., Park Forest, Illinois 60466). The other half of each muscle was kept as a control.

Heat Transfer studies

Steaks ((5.08 cm thick) were sampled from each half muscle at a location adjacent to the center of the whole muscle.

The steaks were heated using a Blodgett convection oven (the G.S. Blodgett Co., Inc., Burlington, Virginia) set at 163C to an internal temperature of 68.3 C. Cooking time and cooking loss were measured.

Shear force measurements

The cooked steaks were cooled for 40 min at room temperature (22-25 C) and chilled for 22-24 hr at 1.1 C to provide adequate firmness and uniform cores. Three cores were sampled from each steak using a mechanical borer. Each core was sheared three times by a Warner-Bratzler shear (J:Chatillon & Sons, New York, N.Y.).

Bacteriological Examinations

The exterior and interior portions of each uncooked BF muscle and the exterior portions of LD and SM muscles were aseptically sampled for bacteriological examinations by removing portions (50g) of the meat tissue. Each sample was blended for up to 2 min using 0.1 percent Peptone (Difco) water.

The Aerobic Plate Count was examined by spreading appropriate dilutions of examined samples on prepoured Plate Count Agar (Difco); plates incubated at 22 C for 48 hr. Total Coliform and Total Enterobacteriaceae were examined using Violet Red Bile Agar and MacConkey Glucose Agar (BBL) respectively, incubated at 35 C for 24-48 hr.

The blade tenderizer was sampled by swabbing 10 cm^2 of the conveyer and two blades (surface area of 59.7cm^2) before, in between, and after the tenderization of the muscles. The tenderizing machine was sanitized using an iodine based sanitizer (Mikroklene DF, Klenzade Products).

Statistical analysis

The results were subjected to the analysis of variance and to the least significant range test (Steel, 1960).

Results and Discussion

Heat transfer

Cooking times of the three muscles used at the different stimulation periods are presented in Table 1. As Table 1 shows, there were no significant ($P<0.05$) differences among blade tenderized muscles and their control for the three stimulation periods. The cooking time of nontenderized "hot boned hot" BF muscle was significantly ($P<0.05$) shorter than the same muscle "hot boned chilled". The cooking time ranged between 71.8 and 126.0 min/kg meat. The cooking time of the "hot boned hot" muscles tends to shorten with the reduction of the stimulation time from 15 to 2 min. This trend and its significance will be further studied.

In all but a few cases the cooking losses of blade tenderized muscles (Table 2) were not significantly different ($P<0.05$) from that of their control. The cooking loss range did not vary among the different stimulation times and was between 22.2 and 36.6 percent.

The results of the heat transfer studies show that electrical stimulation of muscles may prevent larger cooking loss due to tenderization. These results are in contrast to other works (Campbell, 1976; Glover, 1975) which showed a larger cooking loss due to blade tenderization of non-electrically stimulated muscles.

Shear force

The shear force values of the tenderized "hot boned hot" and conventionally processed BF muscles (Table 3) at the three stimulation times were significantly ($P<0.05$) lower than the values of the non tenderized control. This was not case with the "hot boned chilled" treatment. No significant difference ($P<0.05$) was found between the tenderized LD muscle and its control in the different treatments and stimulation times. A significant difference ($P<0.05$) in shear force values was found only between the tenderized and the control of the "hot boned chilled" and conventionally processed SM muscle.

From these results one can see that blade tenderization of the outside and inside rounds improved their tenderness. Using 15 min stimulation periods

Table 1: Cooking time of some electrically stimulated blade tenderized muscles

Treatment	BF	LD	SM	BF	LD	SM	BF	LD	SM
		15*			5*			2*	
					Cooking Time (min/kg)				
Hot Boned Hot***									
NT	71.8±32.7^{ab}**	101.0±31.1	94.0±39.0	117.8±22.3	109.4±13.8	112.0±1.0	91.2−14.8	89.0±11.8	103±13.7
T	87.7±35.2	69.6±15.0^{cd}	96.2±47.5	96.1±14.2	117.8±0.3	100.1±13.1	92.5±18.3	93.8±10.6	85.8±18.8
Hot Boned Chilled (1.1 C, 15 hr)									
NT	115.6±16.2^{a}	117.4±13.6^{c}	115.8±15.5	103.1±10.7	108.3±2.4	101.3±1.0	94.5±3.0	99.2±24.1	117.8±11.0
T	119.3±17.3^{b}	98.5±19.7	104.3±8.1	100.5±3.1	102.2±8.1	97.3±1.0	88.3−28.9	105.5±26.5	99.4±21.8
Conventional Processing (Chilled 1.1 C, 24 hr)									
NT	99.1±9.1	99.6±13.0	100.8±8.0	100.0±10.3	126.0±30.1	111.3±7.5	98.2±11.3	90.5±4.6	103.0±13.4
T	100.4±28.1	111.5±12.0^{d}	121.3±17.7	96.3±19.1	95.4±6.5	101.6±22.9	78.2±6.1	90.9±7.5	95.6±24.1

*Stimulation time (min).
**Numbers with the same superscript letter in each stimulation time are significantly different ($P<0.05$).
***NT=Non-Tenderized; T=Tenderized.

Table 2: Cooking loss of some electrically stimulated blade tenderized muscles

Treatment	BF	LD	SM	BF	LD	SM	BF	LD	SM
		15*			5*			2*	
					(%)				
Hot Boned Hot***									
NT	23.5±3.3^{a}**	25.8±0.9	27.2±2.2	26.0±4.6	24.4±0.8	28.2±0.4^{a}	28.3±1.5	23.6±3.3	26.0±1.0
T	34.1±2.1^{ab}	26.9±5.0^{b}	30.6±6.7	32.5±2.0	26.9±0.3^{c}	36.6±4.1^{ac}	30.5±11.7	25.5±6.6	32.3±0.5
Hot Boned Chilled (1.1 C 15 hr)									
NT	28.0±1.3	24.4±0.7	27.7±2.8	22.2±6.3^{bd}	22.3±3.9^{e}	30.6±2.0^{de}	25.1±3.6^{a}	25.0±1.8	27.8±4.9
T	32.3±1.8^{c}	26.6±3.5^{c}	31.5±5.2	32.5±5.9^{b}	26.0±1.3	32.2±2.8	34.3±3.2^{a}	29.8±0.2	32.0±1.4
Conventional Processing (Chilled 1.1 C 24 hr)									
NT	26.9±3.0	23.8±0.8	27.8±3.6	32.0±2.8^{f}	24.1±1.3^{f}	31.5±2.0	27.5±0.8^{b}	25.5±3.0	28.6±6.5
T	29.3±6.5	27.9±2.9	32.3±2.1	32.0±0.2	28.1±2.8	32.8±1.7	36.1±5.5^{b}	28.5±2.1	32.3±3.8

*Stimulation time (min.)
**Numbers with the same superscript letter in each stimulation time are significantly different ($P<0.05$).
***NT=Non-Tenderized; T=Tenderized.

Table 3: Tenderness (shear force values) of some electrically stimulated blade tenderized muscles

Treatment	BF	LD	SM	BF	LD	SM	BF	LD	SM
		15*			5*			2*	
				(Kg/2.5 cm)					
Hot Boned Hot* **									
NT	13.2±4.4[a**]	11.7±4.9	12.4±2.9	19.0±6.6[ag]	9.9±1.5[g]	16.8±4.0[g]	18.5±4.4[ae]	16.3±2.4	16.5±5.8[h]
T	11.2±1.6[ad]	10.1±3.4[e]	13.0±2.8[de]	11.3±2.3[ah]	9.0±1.4[h]	16.0±3.8[h]	14.4±5.0[af]	15.5±3.2[g]	14.0±1.4[ij]
Hot Boned Chilled (1.1°C, 15 hr)									
NT	12.2±3.0	11.3±2.9	12.5±3.8[b]	12.2±2.1[bi]	7.9±1.5[i]	15.0±3.6[ei]	13.1±6.6[ek]	14.9±4.1	17.3±18[bk]
T	11.4±2.4[f]	10.1±2.7	9.4±2.5[bf]	9.9±2.5[b]	8.1±2.0[j]	11.7±2.6[ej]	14.7±5.5[L]	14.8±4.7[M]	9.9±1.9[bilm]
Conventional Processing (Chilled 1.1°C, 24 hr)									
NT	13.0±4.0[c]	12.2±2.6	13.5±2.4	13.1±2.1[c]	12.5±2.1	14.3±2.9[f]	15.9±4.6[c]	13.7±2.4	13.3±2.8[dh]
T	10.3±3.5[c]	10.8±2.5	11.8±3.5	9.4±2.4[c]	9.1±1.7	9.9±2.7[f]	9.9±3.2[cf]	12.1±1.9[g]	9.7±1.5[dj]

*Stimulation time (min.)
**Numbers with the same superscript letter in each stimulation time are significantly different ($P<0.05$).
***NT=Non-Tenderized; T=Tenderized.

Table 4: Aerobic plate count of some tenderized muscles

Treatment	E*	BF I**	LD*	SM*
Hot Boned Hot***		Count/g		
NT	1.9×10^4	1.0×10^1	1.0×10^1	3.8×10^3
T	1.0×10^1	1.0×10^1	1.5×10^4	6.0×10^3
Hot Boned Chilled (1.1 C, 15 hr)				
NT	7.5×10^3	1.0×10^1	6.5×10^2	3.9×10^3
T	1.0×10^3	1.0×10^1	2.3×10^3	8.0×10^2
Conventionally Processed (Chilled 1.1 C, 24 hr)				
NT	1.0×10^3	1.0×10^1	1.0×10^1	6.0×10^2
T	3.8×10^3	1.0×10^1	1.1×10^3	2.0×10^3

*The exterior portion of the muscle.
**The interior portion of the muscle.
***NT=Non-Tenderized; T=Tenderized.

Table 5: Bacterial count of the tenderizing machine sanitized with an iodine compound***

Treatment	Conveyor (Count/cm²)	Blades (Count/2 Blades)**
	Count Range	
Sanitized before Tenderization*	2.1×10^3 -------- 1.0×10^1	1.0×10^3 ---------- 1.0×10^2
After First Run of Muscles	2.0×10^3 -------- 1.0×10^1	5.0×10^1 ---------- 1.0×10^1
After Second Run of Muscles	5×10^1 -------- 1.0×10^1	5.0×10^1 ---------- 1.0×10^1

*The Iodine compound was left on the machine for two minutes before tenderization started.
**Blade dimensions: height 15.7 cm, length 1.5, width 0.4 cm (the surface area = 59.7 cm^2 or 9.2 in^2)
***Mikroklene DF

resulted in no significant difference ($P<0.05$) between the tenderized BF and tenderized LD muscles in the three treatments. No significant difference ($P<0.05$) was found between the tenderized and non-tenderized LD muscle. One can say that blade tenderization may not improve the tenderness of this muscle.

Bacteriological examinations

The Aerobic Plate Count (Table 4) of the exterior portion of the muscles did not exceed 10^4/g. The Aerobic Plate Count of the exterior portion of the tenderized LD muscle was higher than its control by 10 to 10,000 fold. As shown Aerobic Plate Control of the interior portion of the tenderized BF muscle was not different than that of the non-tenderized control ($<1.0\times10^1$/g). These low counts were obtained due to a good sanitation program including the use of an FDA approved iodine based sanitizer. Table 5 shows that the bacterial contamination of the tenderizing machine was as low as $<1.0\times10^1$ to 2.1×10^3 per cm^2 conveyor or per 2 blades. Meat products with low bacteriological counts have a longer shelf life in refrigeration and the hazard from pathogenic microorganisms is reduced. The level of the Total Coliform and Total Enterobacteriaceae was in all instances $<1.0\times10^1$/g of meat.

Literature Cited

Campbell, J.F. 1976. Proceedings 29th annual reciprocal meat conference of the American Meat Science Association, pp. 253, National Live Stock and Meat Board, Chicago, Illinois 60611.

Davis, G.W. 1976. ibid: pp. 251.

Glover, E. 1975. J. Animal Sci. 41:292.

Steel, R. G. D. 1960. Principles and Procedures of Statistics, McGraw-Hill Book Co., New York.

The Storage Stability Of Electrically Stimulated Hot Boned Refrigerated Ground Beef

M. Raccach and R. L. Henrickson

Story in Brief

The storage stability of electrically stimulated ground beef was studied. An incubation temperature of 22 C was found accurate (correlation coefficient of 0.96) for the estimation of the psychrotrophic bacterial population of the product. Electrical stimulation prolonged the lag phase of the bacterial population but inhanced its growth rate (between the third and fifth days of storage). The shelf life of the electrically stimulated ground beef was extended by 3 days as compared to the nonstimulated control (4-5 vs 7-8 days respectively).

Introduction

The importance of ground beef is increasing every year in the U.S. The present consumption is 18.2 Kg/capita and it is believed that it will reach 22.7 Kg/capita a 25 percent increase (Meat Plant Magazine, 1977).

The bacteriological quality of raw ground beef is of concern to all segments of the industry. Reduced shelf life, discoloration of the product as a result of bacterial growth are often encountered. Goepfert (1976) reported an Aerobic Plate Count (APC) of 5×10^6/g in 34 percent of 955 samples of ground beef examined. Duitshaever (1977) showed that more than 50 percent of 108 samples examined were in the range of 5×10^6 to 5×10^7/g. The source of meat for ground beef and the holding time of the meat may contribute to the bacteriological quality and storage stability of the product. Proposed microbiological standards for ground beef in some states were set at a maximum range of 1.0×10^6 to 5.0×10^6/g (Geopfert, 1976). The United Kingdom has proposed a level of 10^6/g (Green, 1976) while in Canada the maximum limit is 10^7/g (Pivnick, 1977).

Although several studies on the storage stability of ground beef have been completed, there is relatively little, if any, studies on the effect of prefabrication procedures on the microbiological quality and storage stability of the product. The purpose of this study was to show the effect of electrical stimulation and hot boning on the refrigerated storage stability of ground beef.

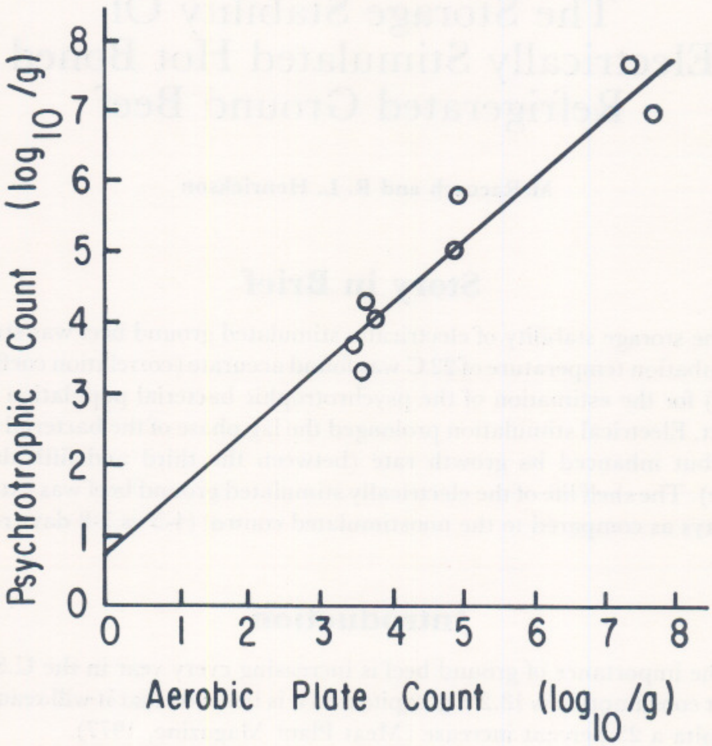

Figure 1. The linear regression between the Aerobic Plate Count and Psychrotrophic Bacterial Count of electrically stimulated hot boned ground beef

Materials and Methods

Electrical stimulation

Sides of beef were stimulated according to Raccach (1978).

Ground beef

Portions of the chuck from the stimulated and control sides were removed at 1.5 hr post mortem, ground then frozen (−25 C) until used.

Bacteriological examinations

Twelve portions each of 250g were packed using a polystyrene foam tray wrapped with PVC (Polyvinyl Chloride). The ground beef was stored at 5 C and a 10g sample was taken daily (22-24 hr). The sample (10g) was blended for 2 min using 90 ml 0.1 percent Peptone (Difco) water. Further dilutions were obtained using the same diluent. The Aerobic Plate Count (APC) was examined by spreading appropriate dilutions of examined samples on pre-poured Plate Count Agar (Difco) plates incubated at 22 C for 48 hr. The Psychrotrophic Bacterial Count (PBC) was examined using the same culture medium incubated at 7C for 10 days.

Calculation of the bacterial number of generations

The number of generations (G) was calculated according to the following formula:

$$G = T/3.3 \log b/B$$

Where: T = Time period; b = number of bacteria at the end of a given time period;
B = Initial number of bacteria.

Shelf life determination

The meat samples were examined for "off odors" by a three member panel. A sample evolving "off odors" was considered spoiled.

Statistical analysis

The correlation and the linear regressions between the APC and the PBC was calculated. The results of the APC of the stimulated sample and its control were subjected to the analysis of variance and to the least significant range test (Steel, 1960.)

Results and Discussion

The linear regression of the APC and the PBC of the electrically stimulated samples (n=6) is shown in Figure 1. The equation of the regression line was $Y=0.78+0.85X$ (where: y=PBC; 0.78=y intercept; 0.85=slope and X=APC). The correlation coefficient (r) was 0.96 significant at $P<0.01$. Figure 2 shows the linear regression of the APC and the PBC of the control (non-electrically stimulated) samples (n=6). The equation of the regression line was $Y=-0.3+1.06X$ with a correlation coefficient (r) of 0.99 significant at

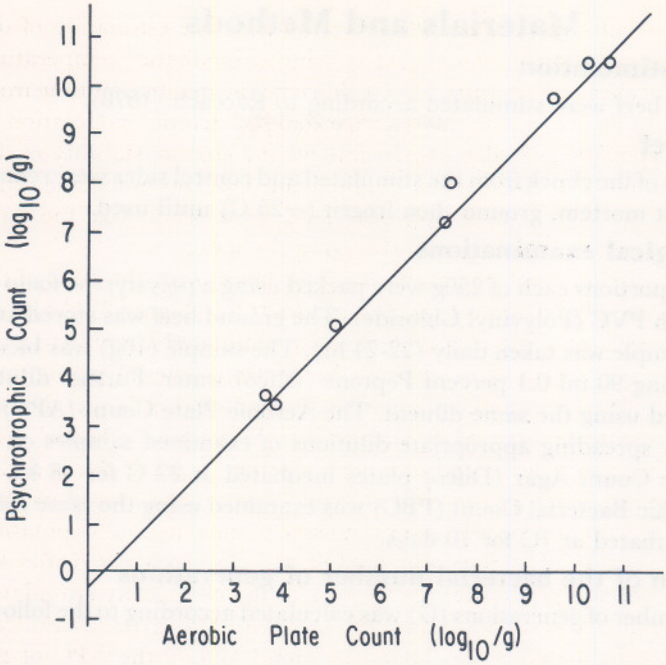

Figure 2. The linear regression between the Aerobic Plate Count and Psychrotrophic Bacterial Count of hot boned ground beef

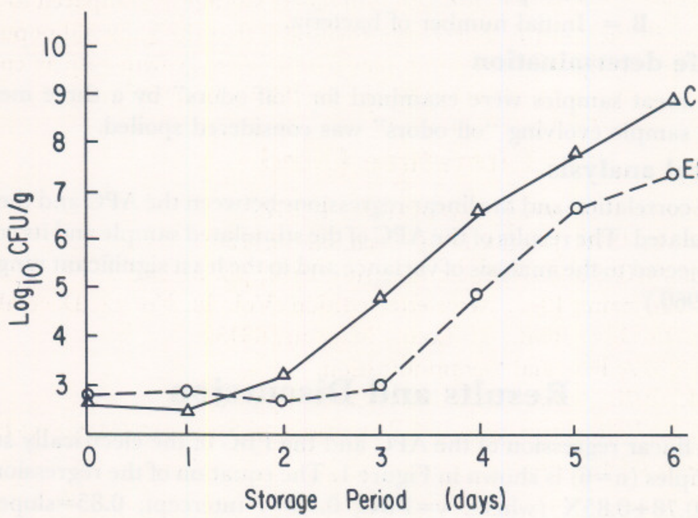

Figure 3. The growth of the endogenous flora of electrically stimulated hot boned ground beef stored at 5 C (C=control; ES=electrically stimulated; CFU=colony forming unit)

P<0.01. These results show that one can get an accurate estimation of the psychrotrophic population of ground beef by using an incubation temperature of 22 C. This elevated temperature (22 C) shortens the incubation time from 10 days (7 C) to 48 hr. Since the psychrotrophic bacterial population is responsible for spoilage it is also responsible for the storage stability of the refrigerated product. It is essential for quality control purposes to have rapid means for estimation of the psychrotrophs' level, in order to take the right measures concerning marketing and processing the meat.

A 22 C incubation temperature was used for monitoring the APC of the electrically stimulated and control samples stored at 5 C(Figure 3). As it can be seen the bacterial population of the electrically stimulated sample had a lag phase of 3 days as compared to 1 day of the control bacterial population. Probably the electrical stimulation impaired the bacterial cells metabolism resulting with an extended lag phase. The shelf life (i.e. time to "off odor") of a refrigerated product in general and of a meat product in particular is determined among other causes by bacterial growth. A processing procedure that will induce a long lag phase and slow growth rate of the bacterial population will also extend the shelf life of the product. "Off odors" were detected after 4-5 days in the control samples but after 7-8 days in the electrically stimulated samples. Electrical stimulation extended the shelf life of the ground beef by 3 days. A significant difference ($P<0.05$) was found among the APC of the electrically stimulated and control samples on the third, fifth and sixth days of storage. The bacterial population of the electrically stimulated sample formed 12.2 generations between the third and fifth day of storage as compared to 9.9 generations with the control. These results showed that the bacterial population of the electrically stimulated samples had a faster growth rate as compared to the control, without affecting the shelf life of the product.

Literature Cited

Duitschaever, C. L., 1977, J. Food Protec. 40:378.

Goepfert, J. M., 1976, J. Milk Food Technol. 39:175.

Green, S. I., 1976, Food Manufacture, July 1976, pp. 51 and 71.

Meat Plant Magazine 1977. Newsletter edition, Vol. 38, No. 12, December 1977. 8678 Olive Blvd., St. Louis, Missouri 63132.

Pivnick, H., 1977, Personal Communication.

Raccach, M., 1978, Animal Science Research Report.

Steel, R. G. D. 1960, Principles and Procedures of Statistics. McGraw-Hill Book Co., New York.

The Effect of Hot Muscle Boning on Lean Yield, Cooler Space Requirements, Cooling Energy Requirements, and Retail Value of the Bovine Carcass

R. D. Noble and R. L. Henrickson

Story in Brief

The increased pressure for energy conservation has accentuated the need for a more efficient method of processing the bovine carcass. By hot muscle boning the carcass and cooling only the edible portion, savings in the space and energy required for cooling may be realized.

Yield of the boneless edible product resulting from hot muscle boning was determined and expressed as a percent of hot side weight. The mean value for yield was 62.3 percent.

Space occupied by the intact side was measured before muscle boning that side. The space required by only the muscle boned product was determined to be 18.86 percent of that needed by the intact side.

The energy (in BTUs) required for a drop in meat temperature from 102 F to 32 F was calculated for the hot muscle boned product and compared to that of the intact side. The mean value was 68.1 percent.

Retail value was calculated and a difference of $16.80 per side favoring the hot muscle boned method was obtained.

Introduction

The removal of muscles and muscle systems prior to initial chilling of the carcass has been investigated in recent years to determine the feasibility of this processing method as a future alternative to conventional bovine fabrication. The eating quality of hot boned beef has been demonstrated to be acceptable (Schmidt and Keman, 1974; Dransfield et al, 1976; Will, 1976) by both objective and taste panel methods.

Several potential advantages of hot boning have been alluded to in the literature. Ramsbottom and Strandine (1949) confirmed that boneless cuts resulting from hot boning were chilled faster than the intact beef sides. It was suggested by Henrickson (1975) that hot boning would eliminate cooling waste fat and bone, and that properly handled hot boned beef would have a lower potential for microbial contamination. Increased yield of boneless meat (Schmidt and Keman, 1974) because of less cooler shrink (Falk, 1974) can be achieved by separating the muscles from the unchilled bovine carcass and vaccum packaging the lean tissue. Even though limited research has been done to specifically evaluate some advantages of hot muscle boning, many areas still need to be investigated. The objectives of this study were to determine the effect of hot muscle boning on the cooling energy and chill space requirements, edible product yield and retail value of the beef carcass.

Materials and Methods

The research was divided into four major phases with a total of 25 cattle being utilized. For all research phases the hot muscles and muscle systems were removed from the side four hours post morterm. The muscles and muscle systems removed were the semimembranosus, semitendinosus, biceps femoris, quadriceps fermoris, gluteus medius, longissimus dorsi, psoas major, supraspinatus, flank steak, inside chuck roast, outside chuck roast, brisket roast, and lean trim for ground beef (approximately 20 percent fat). These cuts were selected in an attempt to maximize the use of the meat from the side as boneless steaks and roasts. The muscles were individually wrapped in Avisco cellophane and placed in a 1 C chill cooler. Bone and fat from each side were weighed. After 48 hours the cuts were trimmed to a maximum external fat thickness of 0.65 cm and weighed. Rib eye area, fat thickness, and percent kidney, pelvic, and heart fat were measured on the opposite side.

Yield

Twenty-five steers and heifers of mixed breeding were slaughtered according to normal procedures and each carcass split into right and left sides. One side from each carcass was randomly assigned for hot muscle boning. The percent yield of boneless, edible meat was calculated by dividing the total weight of the hot muscle boned product by hot side weight.

Cooler Space Requirement

One side of each of sixteen carcasses was randomly assigned to the hot muscle boning treatment. Each side was measured using a tape for length, width, and depth at its longest, widest and deepest points to determine the space in cubic centimeters occupied by that side hanging from the rail in the cooler. After obtaining these measurements, the side was hot muscle boned. The resulting product was cooled at 1 C to permit it to condition so more precise measurements could be obtained. Each individual muscle or muscle system was trimmed to 0.65 cm maximum external fat and then measured to determine its space requirements. The combined space occupied by all the cuts from each side was then calculated.

Cooling energy

The amount of heat energy transfer (cooling energy) required to chill the meat was investigated using 25 sides. The energy transfer in kilocalories necessary for 1 C drop in meat temperature was obtained by multiplying the weight of the meat by the specific heat of the meat. Specific heats of 0.75 and 0.82 kilocalorie per kilogram per degree Celsius for the intact side and lean beef respectively (American Society of Heating, Refrigeration, and Air Conditioning Engineers, 1974; Morely, 1972) were used in the calculation.

Retail value

Eight carcasses were used to compare the retail value of the hot muscle boned side to the value of the opposite conventionally cold processed side. After slaughter, one side of each carcass was placed in a 1 C chill cooler while the other side was hot muscle boned. Forty-eight hours after hot boning the muscles and muscle systems were further processed into retail cuts. Following a seven day chill the opposite side was fabricated into bone-in retail cuts according to conventional cutting procedures. Retail value for each side was calculated using retail prices obtained November 23, 1976 from retail outlets in Stillwater, Oklahoma.

Statistical analysis

The research was designed to be analyzed as a completely randomized block design with each carcass comprising one block. The Analysis of Variance in conjunction with the F-test was used to analyze differences in the space, energy and retail value comparisons.

Results and Discussion

Mean values of various carcass traits of the cattle utilized are presented in Table 1. The mean side weight was 124.96 Kg, and the average USDA Yield Grade was 3.23. These values are reported only as a description of the population of cattle used, since no attempt was made to relate these traits to the results of this study.

Yield

The percent yield of lean, fat, and bone components of the hot muscle boned sides appear in Table 2. An average of 62.4 percent of side weight was recovered in boneless, lean beef. This lean yield value compared very closely to the yield reported by Schmidt and Keman (1974) who found a significantly great yield from hot boning when compared to the opposite side of the carcass which was cold boned after an eight day chill. In the present study the opposite side was not available for cold boning, so no direct comparison could be made.

Space

Mean cooler space requirements for the intact side and the hot muscle boned product are compared in Table 3. Less ($P<.01$) space is occupied by the

Table 1. Beef carcass trait means

Trait	Mean Value	S.E.
Side Weight (kg)	124.96	4.64
Rib Eye Area (sq. cm)	64.48	1.87
Kidney, Pelvic, and Heart Fat (%)	3.58	0.18
Fat Thickness at 12th Rib (cm)	1.19	0.13
Yield Grade	3.23	0.18

Table 2. Composition of hot muscle boned sides

Component Yield %	Mean Value	S.E.
Lean	62.40	0.64
Fat	19.70	0.72
Bone	15.82	0.45

Table 3. Space Requirements for Intact Side and Hot Muscle Boned Product

	Mean Cooler Space Requirement (cu cm)	S.E.
Intact Side	648,199.33	39,747.48
Hot Muscle Boned Product	122,818.26[a]	6,541.72
Space Saved	80.78%	

[a]Significant difference ($P<.01$)

Table 4. Heat energy transfer requirements for intact side and hot muscle boned product

	Mean Heat Energy Transfer (Kcal)	S.E.
Intact Side	93.72	3.48
Hot Muscle Boned Product	63.70[a]	2.43
Heat Energy Saving	31.77%	

[a]Significant difference ($P<.01$)

Table 5. Mean side retail value for hot and cold processing methods

Method	Side Value ($)	S.E.
Hot	271.98[a]	5.61
Cold	254.85	5.00
Increased retail value	$17.13	

[a]Significant difference ($P<.01$).

hot muscle boned product, and if expressed as a percent of the intact side, only 19.12 percent as much space is needed. This can be explained by the fact that a substantial amount of space is wasted by the intact side due to curves and protrusions such as the foreshank. The hot muscle boned pieces are not as irregularly shaped, and space needed to chill bone and excess fat is eliminated.

Cooling energy

A comparison of heat energy transfer requirements for the intact side and the hot muscle boned lean is shown in Table 4. Less (P<.01) heat energy transfer is necessary for the hot muscle boned product, and only 68.23 percent as much as is required for the intact side. The difference is simply because bone and excess fat are not chilled. These values represent only the amount of heat energy transfer within the product, so the actual energy savings will depend on the efficiency of the chilling system. Only a 1C drop in meat temperature is represented, but the energy transfer relationship between the hot muscle boned product and the intact side would be identical regardless of how large a temperature drop (above freezing) was achieved.

Retail value

Mean side retail values for the hot and cold cutting procedures are compared in Table 5. The hot boned side has a greater (P<.01) retail value than the conventionally cold, bone-in processed side with a difference of $17.43 per side. There are three major reasons for the increased value of the hot muscle boned side. First, there is more lean beef recovered because of less weight due to cooler shrink. Second, more of the meat from the hot muscle boned side was more efficiently utilized as higher priced steaks and roasts. Third, the price per unit of weight is greater for the boneless cuts, partially due to the additional labor required to remove the bone from the retail cut.

The beef carcass has a greater retail value as a result of hot muscle boning. Significant savings in the energy and space required for cooling the meat may also be realized. Therefore, hot muscle boning offers the meat industry a more efficient method of processing the beef carcass.

Literature Cited

American Society of Heating, Refrigeration, and Air Conditioning Engineers, 1974. *Guide and Data Book*, New York, New York, pp. 27.1-27.24.

Dransfield, E., A. J. Brown, and D. N. Rhodes, 1976. Eating quality of hot deboned beef, J. Food Technol., 11:401.

Falk, S. N. 1974, Meat quality changes resulting from prerigor muscle boning of the bovine carcass. U.S. Dept. of Agric., Agricultural Research Service Agreement No. 12-14-100-10-867 (51).

Henrickson, R. L., 1975, Hot Boning. *Proceedings of the Meat Industry Research Conference*. p. 25.

Morely, M. J., 1972, Thermal Properties of Meat: Tabulated Data, Meat Research Institute Special Report No. 1, Meat Research Institute, Langford, Bristol, BS 18 7DY.

Ramsbottom, J. M. and E. J. Strandine, 1949, Initial physical and chemical changes in beef as related to tenderness, J. Animal Sci. 8:398.

Schmidt, G. R. and S. Keman, 1974, Hot boning and vacuum packaging of eight major bovine muscles, J. Food Sci. 39:140.
Will, P. A. 1974, The influence of delayed chilling on beef tenderness. M.S. Thesis. Oklahoma State University, Stillwater.

Changes in the Activity of Certain Muscle Glycolytic and Oxidative Enzymes During Feedlot Growth in Cattle

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

Story in Brief

Muscle tissue obtained from Hereford and Charolais crossbred steers slaughtered at 500, 700 and 900 lb was analyzed for anaerobic and aerobic enzyme activity. Lactate dehydrogenase and Glyceraldehyde phosphate dehydrogenase were chosen to represent enzymes of the anaerobic or glycolytic pathway; while Succinate dehydrogenase and Malate dehydrogenase were selected to represent enzymes of the oxidative pathway. Results indicated that glycolytic enzyme activity decreased during feedlot growth and oxidative enzyme activity increased, suggesting greater activity of the Type I muscle fibers than is commonly believed at this period of life in mammals.

Introduction

Beef muscle is made up of a mixture of Type I and Type II muscle fibers. These fibers greatly differ in their growth potential, growth impetus and metabolic characteristics. Type I fibers are slow contracting, exhibit mostly aerobic metabolism and are smaller than the Type II fibers, which are fast contracting and are primarily anaerobic in their metabolic capabilities. Work with various species of animals suggests that muscle metabolism adapts from a highly aerobic or oxidative state, in the newborn to a highly glycolytic or anaerobic state in the adult. Nevertheless, little quantitative data are available to indicate the changes occurring in specific glycolytic and oxidative muscle enzymes during feedlot growth and development of cattle. Thus the objective of this study was to quantitate changes in the activity of certain "indicator" enzymes occurring in beef muscle during feedlot growth; for such subtle alterations at the ultrastructural level in muscle could influence or control the changes observed in the gross composition of cattle.

Materials and Methods

Muscle samples were obtained from fifteen Hereford and Charolais crossbred steer calves. Five of the steers were slaughtered at each of the following weight groups: 500 lb, 700 lb and 900 lb. Tissue was removed from the 12th-13th rib area of the right longissimus dorsi within 10 min postmortem and immediately prepared for enzyme analysis. Twenty grams of minced muscle tissue were extracted in five volumes of ice cold, buffered sucrose solution containing 100mM EDTA, 42mM Tris-HCL, 8mM Tris-Base, 50 units/ml Heparin and 250mM Sucrose. Extraction pH was 7.4. The protein concentration of all extracts was determined by the method of Lowery, et al, 1951 (J.B.C., 193:265).

Lactate dehydrogenase and Glyceraldehyde phosphate dehydrogenase were chosen to represent the glycolytic enzymes and Succinate dehydrogenase and Malate dehydrogenase were selected to represent the oxidative enzymes. The activity of these enzymes was determined by procedures modified from those of Long, 1961 (Biochemists Handbook, D. VanNostrand Co.) and King, (J.B.C. 238:4032).

Results and Discussion

Anaerobic metabolism

As shown in Table 1 the activity of two key glycoltyic enzymes, Lactate dehydrogenase (LDH) and Glyceraldehyde phosphate dehydrogenase (GPD), decreased as feedlot weight increased. LDH activity dropped 130.8 international units (IU) between the 500 and 700 lb weight groups, then increased 52.4 IU between the 700 and 900 lb weight groups. Overall, there was a decrease of 78.4 IU or 18 percent in the activity of this enzyme during the feedlot period. The observed significance level of this change was 0.40, higher than that usually required to ascribe statistical significance.

GDP activity decreased 1.4 and 0.4 IU between the 500-700 and 700-900 lb weight groups, respectively. Percentage-wise, the overall drop in GPD activity was 85.7 percent. This was significant at the 0.06 level of probability.

Aerobic metabolism

Both Succinate dehydrogenase (SDH) and Malate dehydrogenase (MDH) displayed highly significant increases (O.S.L.=0.001 and 0.02, respectively) in activity during feedlot growth (Table 2). The overall change in

Table 1. Glycolytic enzyme activity in longissimus muscle of 500, 700 and 900 lb steers

Slaughter Weight Group (lb)	Lactate Dehydrogenase Activity (IU)	Glyceraldehyde Phosphate Dehydrogenase Activity (IU)
500	434.9	2.1
700	304.1	0.7
900	356.5	0.3

Table 2. Oxidative enzyme activity in longissimus muscle of 500, 700 and 900 lb steers

Slaughter Weight Group (lb)	Succinate Dehydrodenase Activity (IU)	Malate Dehydrogenase Activity (IU)
500	6.3	0.6
700	27.8	1.1
900	38.4	2.4

muscle SDH activity during feedlot growth was 32.1 IU, which was equivalent to an 83.6 percent increase. MDH activity increased 1.8 IU or 75 percent during this period.

Growth Rate and Carcass Characteristics Of Hereford Steers and Hemicastrate-SS Bulls

R. P. Wettemann, L. W. Brock, R. W. Fent and D. G. Wagner

Story in Brief

Hereford bulls between 1 and 3 months of age, were castrated or hemicastrate-short scrotum (SS) bulls were produced to determine the influence of the presence of one sterile testis on growth rate and carcass characteristics. Preweaning daily gain was similar for the two groups. During 219 days in the feedlot, hemicastrate-SS bulls had greater daily gain than steers. Carcass grade was reduced in hemicastrate-SS bulls compared to steers, and they had slightly greater rib eye areas.

These data suggest that although hemicastrate-SS bulls have increased gain compared to steers they have the undesirable carcass characteristics which have been reported for bulls and short scrotum bulls.

Introduction

Increases in average daily gain and feed efficiency can be achieved by implanting cattle with commercial implants containing sex hormones such as estradiol, testosterone or progesterone. As a substitute for implanting, it would be desirable to allow a bull's natural testicular hormones (androgens) stimulate growth rate. Although intact bulls have increased daily gain and increased feed efficiency compared to steers, their carcasses are less valuable because of decreased marbling and quality grade. In addition, an intact fertile bull may breed heifers and cows with which they are associated.

Shortening the scrotum of bulls keeps the testes closer to the body and exposes the testes to higher temperatures. Bulls with short scrotums produce less normal sperm and the bulls are usually sterile. Although shortening the scrotum solves the problem of bulls breeding females, numerous studies have demonstrated that short scrotum bulls have growth and carcass characteristics similar to normal intact bulls.

The objective of the present experiment was to determine if removal of one testis and initiation of sterility of the other testis by placing it close to the body cavity (hemicastration-short scrotum) would create an animal with growth characteristics similar to bulls and carcass characteristics similar to steers.

Materials and Methods

Hereford bulls between 1 and 3 months of age were allotted to one of the two treatments. Twelve steers were produced by cutting the bottom of the scrotum with a knife and removing both testes. Thirteen hemicastrate-short scrotum (SS) bulls were produced by locating one testis in the top of the scrotum next to the body wall and placing a tight rubber band below it with the remaining testis situated in the bottom of the scrotum. Within 7 to 10 days the lower part of the scrotum and the lower testis would necrose and fall off, leaving a short scrotum with only one testis in it.

Animals were weaned at 6 months of age and placed on a growing ration for 3 months. The animals were full fed for 219, until steers appeared that they would grade low choice.

Table 1. Daily gain (pounds) of steers and hemicastrate-SS bulls during different growing periods

Period	Age	Treatment	
		Steers	Hemicastrate bulls
	(mo)		
Animals (no)	---	12	13
Preweaning	2 to 6	1.48±.33	1.46±.13
Growing	6 to 9	.98±.07	1.05±.07
Feedlot[a]	9 to 16	2.21±.05	2.40±.08

[a]Significantly different (P<.10).

Table 2. Characteristics of steers and hemicastrate-SS bulls during the feedlot phase

Item	Treatment	
	Steers	Hemicastrate-SS bulls
Animals (no)	12	13
Feeding period (days)	219	219
Initial weight (lb)	437± 8	418±16
Final weight (lb)	919±12	943±23
Total gain (lb)[1]	468±18[a]	525±28[b]
Hot carcass weight (lb)	592± 7	606±19
Carcass grade[1,2]	10.1±.4[c]	8.9±.4[d]
Yield grade[3]	3.2±2	3.0±.2
Fat thickness (in)	.6±.1	.6±.1
Rib eye area (in^2)	11.0±.3	11.6±.4

[1]ab: Values with different superscripts differ significantly (P< .10).
cd: Values with different superscripts differ significantly (P<.05).

[2]U.S.D.A. grade converted to the following numerical designations: 8=avg good, 9=high good, 10=low choice, 11=avg choice, 12=high choice

[3]1=highest and 5=lowest

Results and Discussion

Daily gain for the steers and hemicastrate-SS bulls during the preweaning, growing and feedlot periods are listed in Table 1. Before weaning, steers and hemicastrate-SS bulls grew at similar rates. This would be expected since the testes of normal bulls would only produce small quantities of androgens during this age period. Growth rate was not significantly different during six to nine months of age although the hemicastrates gained slightly more than the steers (1.05 *vs* .98 lb per day). During the feedlot phase, the hemicastrate bulls had greater daily gain ($P<.10$) than the steers. This indicates the one testes close to the body cavity produces sufficient androgens to enhance growth rate. During this period, the hemicastrates developed some of the body characteristics that are typically associated with bulls.

Table 2 contains the feedlot performance data. Total gain during the 219 day feeding period was greater ($P<.10$) for hemicastrate-SS bulls (525 lb) than for steers (468 lb). Carcass grade was reduced ($P<.05$) in the hemicastrate-SS bulls. The average grade of the hemicastrates was slightly less than high-good; whereas, the steers were slightly above low-choice. Yield grade and backfat thickness were similar for the two groups. The rib eye area was slightly greater in hemicastrate-SS bulls than the steers but the difference was not significant.

The results of this experiment indicate that only one testis close to the body cavity (hemicastrate-SS) in bulls produces sufficient androgens to increase growth rate compared to steers. However, associated with the increased feedlot growth rate is a reduction in carcass grade.

Muscle Fiber Count Per Tissue Slice By Photomicrographic and Coulter Counter Techniques

J. J. Guenther and R. V. Felber

Story in Brief

Fiber numbers per tissue slice were determined on the longissimus dorsi, sartorius, semitendinosus and triceps brachii muscles taken from the left and right sides of 5 fifteen-day-old dairy calves at three locations on the long axis of the muscles. The number of fibers was determined by a photomicrographic and by a coulter counter enumeration technique developed for this experiment. No significant differences in fiber number were observed between sides by either counting method. Significant location differences in fiber count per tissue slice ($P<.05$) were noted in the longissimus dorsi and semitendinosus muscles by the photomicrographic method, but not by the coulter counter procedure. The photomicrographic technique gave consistently higher fiber counts than the coulter counter procedure, but results from both methods ranked the test muscles in the same order. Correlation coefficients between the two procedures were significant for fiber count in the longissimus dorsi and semitendinosus, but not for the triceps brachii and sartorius muscles. Both fiber enumeration techniques were sensitive in ranking the test calves according to their expected number of muscle fibers; however, the coulter counter procedure affords rapid, automated counting of many samples and eliminates the human fatigue factor inherent in the microscopic procedures.

Introduction

The number of muscle fibers comprising a muscle is believed to be genetically determined and firmly established at birth or shortly thereafter in cattle. Subsequent increases in muscle size during pre- and post-weaning development are due to the enlarging or growth of individual muscle fibers. Hence, if a procedure could be devised to determine the number of muscle fibers contained in a "representative" muscle(s) and this procedure could be imposed on live beef calves in early life, the process of identifying beef animals having the potential for heavy muscling might be accomplished more rapidly and efficiently.

The estimation of fiber numbers in small muscles of laboratory animals has usually been accomplished by microscopic procedures. However, microscopic studies are tedious, time consuming and thus self-limiting when attempting to estimate fiber numbers in the large muscles of meat animals. In recent years, however, the Coulter Corporation has developed automated equipment which may be used to enumerate particles in suspension.

The objectives of this study were to devise procedures to utilize the Coulter equipment in estimating fiber number in muscles from calves and to assess the relationship between the coulter results and those obtained by a photomicrographic technique developed in our laboratory.

Materials and Methods

The longissimus dorsi (4th rib-3rd L.T.), Sartorius, Semitendinosus and Tricepts brachii (lateral head) muscles taken from the left and right sides of five, fifteen day old dairy calves provided the experimental material for this test. Two Holsteins, one Ayrshire, and two Jersey calves were used. All muscles were removed from the freshly slaughtered calves, packaged in aluminum foil, frozen in liquid nitrogen and stored at-20 C until hisological measurements were obtained.

The muscles were sectioned, transversely, at 25, 50 and 75 percent of their long axis. Cross-sectional area at each location was determined. A core sample, ¼ inch diameter was removed at random from each of the above locations and placed in buffered saline until thaw rigor was completed. The core samples were then positioned on a microtome chuck and re-frozen with Cryokwik. Tissue sections, 20 microns thick, were obtained using a Slee Cryostat. These tissue slices were used for fiber enumeration by the two procedures.

Fiber number by the photomicrographic technique

Tissue slices were attached to glass slides, stained with thionin and covered with a glass coverslip. Photomicrographs of two random microscopic fields were taken for each tissue slice. The micrographs were made at 100 power, with a 1 mm^2 ocular grid located in the focal plane of the microscope. Muscle fibers within 5×5 squares of the ocular grid were counted for each field within a tissue slice. Fiber count per field was adjusted to a total count per tissue slice.

Fiber number by the coulter counter techniques

Tissue slices were placed in an accuvette vial filled with buffered saline and disrupted into individual cells by sonification. Three one-half milliliter counts were obtained per tissue slice using a ZBI Coulter Counter. The half-milliliter counts were adjusted to total count per tissue slice.

Results and Discussion

Tables 1 and 2 present the muscle fiber counts per tissue slice obtained on the left and right longissimus dorsi, sartorius, semitendinosus and triceps

Table 1. Influence of side on muscle fiber count per tissue slice in four calf muscles determined by a photomicrographic technique

Side	Muscle			
	Longissimus Dorsi	Sartorius	Semitendinosus	Triceps Brachii
Left	95.7[1]	62.2	66.9	62.2
Right	86.3	64.4	69.3	65.4
Average	91.0	63.3	68.1	63.8

[1]Mean fiber count in thousands.

Table 2. Influence of side on muscle fiber count per tissue slice in four calf muscles determined by a coulter counter technique

Side	Muscle			
	Longissimus Dorsi	Sartorius	Semitendinosus	Triceps Brachii
Left	71.6[1]	48.5	52.5	48.9
Right	67.4	46.9	54.2	48.0
Average	69.5	47.7	53.5	48.5

[1]Mean fiber count in thousands.

Table 3. Influence of location on muscle fiber count per tissue slice in four calf muscles determined by a photomicrographic technique

Location	Muscle			
	Longissimus Dorsi	Sartorius	Semitendinosus	Triceps Brachii
25%[1]	100.6[2]	62.5	68.8	63.4
50%	84.8	64.4	61.9	63.6
75%	87.5	63.0	73.5	64.3

[1]Percent of the long axis of the muscle.
[2]Mean fiber count in thousands.

brachii muscles by the photomicrographic and coulter counter procedures. The photomicrographic enumeration technique yielded consistently higher fiber counts than the coulter counter technique. No statistically significant difference in fiber count was noted between the left and right sides for any of the test muscles by either counting procedure. Moreover the test muscles were ranked longissimus dorsi>semitendinosus>triceps brachii>sartorius in fiber number by both enumeration methods. The average count was 91.0, 68.1, 63.8, and 63.3 thousand muscle fibers per tissue slice for the longissimus dorsi, semitendinosus, triceps brachii and sartorius muscles, respectively, by the photomicrographic method and 69.5, 53.5, 48.5 and 47.7 thousand fibers for these muscles, respectively, by the Coulter counter method.

Tables 3 and 4 show the number of muscle fibers per tissue slice at the three test locations along the muscles obtained by the two enumeration procedures. Significant location differences in fiber count per tissue slice ($P<.05$) were noted in the longissimus dorsi and semitendinosus muscles by

Table 4. Influence of location on muscle fiber count per tissue slice in four calf muscles determined by a coulter counter technique

Location	Muscle			
	Longissimus Dorsi	Sartorius	Semitendinosus	Triceps Brachii
25%[1]	73.3[2]	46.6	55.5	43.9
50%	64.8	49.2	49.5	47.5
75%	70.5	47.2	55.0	48.5

[1]Percent of the long axis of the muscle.
[2]Mean fiber count in thousands.

the photomicrographic method; however, no statistically significant differences, due to location, were observed in tissue slice fiber number with the Coulter counter procedure.

Correlations between the two enumeration methods were significant for the longissimus dorsi (r=.864. $P<.01$) and the semitendinosus (r=.528. $P<.05$) muscles, but not for the triceps brachii and sartorius muscles.

Animals, though not specifically tested, ranked Holstein>Ayrshire>Jersey in total number of fibers per tissue slice.

REPRODUCTIVE PHYSIOLOGY

Response of Cows to Repeated Treatments With PMS

E. J. Turman, R. P. Wettemann and J. G. MaGee

Story in Brief

A single injection of 2000 IU PMS was given on day 17 of the estrous cycle to 14 Angus cows that had never previously been treated with PMS, and to 11 Angus cows that had received PMS the previous year. A third group of 11 cows that had been treated with PMS the previous year received 1500 IU PMS on day 5 and 2000 IU PMS on day 17 of the cycle.

Treatment with PMS the previous year reduced the superovulatory response of cows to PMS. Cows that had never been previously treated had a significantly greater ovulation rate (5.3 *vs* 1.8) a wider range in ovulations (1-16 *vs* 0-5) and more cows ovulating four or more eggs (45 percent *vs* 9 percent) than did cows that had been previously treated. Although the differences were not significant, cows previously treated with PMS and given only a single injection of PMS on day 17 had a slightly greater ovulation rate (1.8 *vs* 1.4) and more cows ovulated two or more eggs (45 percent *vs* 18 percent) than did similar cows receiving PMS on both day 5 and day 17.

The results obtained in this study indicated that treatment with PMS one year will adversely affect the response to PMS the subsequent year. It further suggests that this adverse effect is more marked in cows receiving the sequence of two PMS treatments.

Introduction

The induction of multiple births in beef cows by the injection of pregnant mare serum (PMS) has been the subject of considerable research by the Oklahoma Agricultural Experiment Station. This research has been conducted since 1968 in cooperation with the U.S.D.A. at the Southwest Livestock and Forage Research Station. It has demonstrated that approximately one cow in every four treated with a sequence of two injections of PMS can be expected to respond with a multiple birth. However, it has also revealed a

In cooperation with USDA, Science and Education Administration, Southern Region.

number of problems associated with PMS treatments that greatly limit its use in practical production.

The results obtained in recent years has suggested that PMS injections given one year may adversely affect the superovulatory response of cows to a sequence of two PMS injections given the following year. This was reported in the 1977 Animal Science Research Report (MP-101, page 157). A marked refractoriness to repeated PMS treatments would greatly limit the use of this technique in practical production since cows could be treated only once in their life. Therefore, it was important that this limitation be investigated further to see whether it applied only to the sequence of two PMS injections or would also be a limiting factor in the response of cows to a single injection of PMS.

The purpose of this experiment was to compare the response to a single injection of PMS in cows that had never been previously injected with PMS to those that had received PMS the previous year. In addition a comparison was made of the response of cows that had been previously treated with PMS that were given either a single injection or a sequence of two PMS injections.

Materials and Methods

This experiment utilized 36 lactating Angus cows that were observed in heat between May 8 and July 3, 1977. The cows were maintained on native grass pastures at the Southwest Livestock and Forage Research Station, El Reno. Fourteen of the cows had never been previously treated with PMS. The remaining 22 cows had received a sequence of two PMS injections (1500 IU on day 5 and 2000 IU on day 17) the previous year.

Starting May 5, the herd was checked twice daily for the occurence of heat. Heat detection was aided by the use of vasectomized bulls wearing chin ball markers. When the cows that had previously been injected with PMS were detected in heat, they were alternately assigned to either Treatment II or III. All cows that had not been previously treated with PMS were assigned to Treatment I.

The three treatments used in this experiment were: Treatment I (no previous PMS) 2000 IU PMS on day 17 of the cycle designating day of heat as 0; Treatment II (previous PMS) 2000 IU PMS on day 17; Treatment III (previous PMS) 1500 IU PMS on day 5 and 2000 IU PMS on day 17. All injections were made subcutaneously in the shoulder region. Following the day 17 injection, all cows were fitted with a K-Mar heat detector patch and placed in a lot with a fertile bull. The bull was also equipped with a chin ball marker to further aid in detection of heat following treatment.

The PMS used in this study was a lyophilized product that had been obtained in bulk from Argentina in 1973 and standardized to a potency of 200 IU/mg. It had been stored continuously in a freezer at −10C. About one month prior to use, it was diluted and assayed for potency in 21 day old female

Table 1. Response following PMS treatment of cows with or without a history of previous PMS treatments

	Treatments		
	I	II	III
	No previous PMS	Previous PMS	
Item	PMS day 17	PMS day 17	PMS days 5 and 17
Number of cows	14	11	11
No. observed in heat	12	10	8
Interval - PMS to heat, days	4.5	4.5	5.4
Ovulation rate	5.3	1.8	1.4
Ovulation range	1-16	0-5	0-5
No. of cows with:			
0 ovulation	0	1	3
1 ovulation	7	5	6
2 ovulations	1	2	0
3 ovulations	0	2	0
4+ ovulations	6	1	2

rats using the World Health Organization Standard PMS preparation. For purposes of treatment the PMS was dissolved in sterile saline so 5 ml would contain the quantity required per injection. Ovulation rates were determined in all cows by high lumbar laparotomies performed seven to fourteen days after breeding.

Results and Discussion

The response of the cows to the PMS treatments is presented in Table 1. There were no differences in the estrual response of the two groups of cows (Treatments I and II) that received only a single injection of PMS. However, slightly fewer of the cows receiving the sequence of two PMS injections (Treatment III) were observed in heat (73 percent compared to 86 percent and 91 percent for Treatments I and II, respectively). In addition cows receiving PMS on both days 5 and 17 had a slightly longer interval from treatment to standing heat. Since these differences were not statistically significant they can only be considered to be trends that may or may not represent real differences between the treatments.

The superovulatory response of the cows to PMS as reported in Table 1 does appear to be adversely influenced by PMS treatment the previous year. The cows of Treatment I that had never previously been treated with PMS had an average ovulation rate of 5.3 eggs. This was significantly greater than the average ovulation rates of the cows of Treatments II (1.8) and III (1.4) that had been previously treated with PMS.

Another indication of the enhanced superovulatory response of the cows is the range of ovulations. The range for the cows that had never previously received PMS was 1-16, compared to 0-5 for the two groups that had received PMS the year before. A total of 50 percent of the cows of Treatment I had superovulated, that is ovulated two or more eggs. This was similar to the response observed in Treatments II with 45 percent.

Although the ovulation of four or more eggs is not desirable from the standpoint of the production of multiple births, it does indicate increased superovulatory response of the cow to PMS. The fact that 43 percent of the cows of Treatment I had four or more ovulations, compared to only 9 percent of the cows of Treatment II appears to be strong evidence that previous treatment with PMS reduces the superovulatory response to later treatments.

It is obvious that the previous treatment with PMS reduced the superovulatory response of the cows in this study to PMS. The data reported in Table 1 also suggests that that response was further reduced in cows that received PMS on day 5 as well as day 17. Of the cows previously treated with PMS, 45 percent superovulated when treated only on day 17 compared to only 18 percent of those receiving PMS on both day 5 and day 17. The reasons for this reduced response could not be determined from the data obtained in this study.

The results obtained in this study confirms the trends observed in earlier studies. The treatment of cows with PMS one year will adversely affect their respons to PMS in the succeeding year. A greater reduction in response results when the cows are treated with a sequence of two injections the second year. Therefore, the sequence of two injections of PMS should be given only to cows that have never been previously treated with PMS. Once a cow has been treated with PMS she should receive only a single injection in subsequent years.

Endocrine Changes Associated With Heat Stress Of Gilts After Breeding

D. L. Kreider, R. P. Wettemann
R. K. Johnson and E. J. Turman

Story in Brief

Twenty-four crossbred gilts (Yorkshire X Hampshire) were used to evaluate endocrine function in gilts during and after exposure to elevated ambient temperature on days 1 through 8 postbreeding. Cannulae were placed in the anterior venae cavae of gilts 6 to 12 days prior to estrus. Gilts were mated to a boar on the first day of estrus (day 0) and were artificially inseminated on day 1. Heat stressed gilts were exposed to 35±1 C for 12 hr and 32±1 C for 12 hr daily. Control gilts were maintained at 23±1 C. Gilts were bled at 8 am and 8 pm on days 1 through 8 and were removed from the environmental chambers at 8 pm on day 8 and were bled once daily through day 22 postbreeding. Respiratory rates and rectal temperatures were greater in heat stressed than control gilts. Plasma progesterone in nonpregnant gilts was greater in heat stressed than in control gilts during days 9 to 13 postbreeding. Plasma concentrations of LH and total corticoids in nonpregnant heat stressed and control gilts were similar during exposure to elevated ambient temperature, but plasma estradiol concentrations were slightly reduced during heat stress.

Introduction

With an increase in the number of large scale swine confinement systems, farrowing occurs during all months of the year. Reduced litter size and decreased conception rates have been observed during the months of elevated ambient temperatures.

It has been demonstrated that exposure of gilts to elevated ambient temperature from 0 to 16 days postbreeding results in lowered conception rates and reduced litter size at 30 days postbreeding. However, the physiological causes of this reduced reproductive performance following heat stress in gilts is unknown.

The reduction in sow reproductive performance could be the result of a direct effect of elevated body temperatures upon the embryo or it could be related to changes in the uterine environment caused by alterations in endocrine function. These changes in the uterine environment could affect the ova prior to fertilization, or interfere with the development and implantation of the fertilized ova.

Plasma hormone concentrations associated with early pregnancy and embryogenesis in swine have been studied; however, little information is available on the effects of elevated ambient temperature on endocrine function in gilts. An evaluation of these changes could lead to the development of management practices which would result in improved reproductive performance in swine.

This study was designed to determine the effects of heat stress of gilts on conception rates, embryo survival and on plasma concentrations of progesterone, estradiol, LH and corticoids.

Materials and Methods

Twenty-four crossbred (Yorkshire × Hampshire) gilts, 7 to 12 months of age, were used in this study conducted during the months of July through December.

A boar was used once daily to check gilts for estrus. After each gilt had exhibited at least one normal estrous cycle, and 6 to 12 days prior to expected estrus, gilts were anesthetized with sodium thiopental and cannulae were inserted into the anterior venae cavae.

Gilts were allowed to mate with a boar on the first day of estrus (day 0) and were artificially inseminated on day 1. A blood sample was collected immediately after breeding at 8 am on day 0 and another sample was obtained at 8 pm, then the gilts were randomly allotted to either cool or hot environmental chambers. The cool chamber was maintained at 23±1 C and the hot chamber was maintained at 35±1 C from 8 am to 8 pm and at 32±1 C from 8 pm to 8 am. Gilts in each chamber were confined in two 2 × 5 ft crates and were exposed to 12 hr of artificial light daily (8 am to 8 pm) with 50 percent relative humidity.

During confinement gilts were bled daily at 8 am and 8 pm. Gilts were given 4 lb of feed at each bleeding and water was provided free choice. At 8 pm on day 8, gilts were removed from the environmental chamber and returned to the swine barn where the ambient temperature ranged from 10 to 27 C. They were maintained in individual crates or pens and blood samples were collected once daily through day 22 postbreeding. Gilts were slaughtered at 32±5 days postbreeding and numbers of embryos and corpora lutea were determined.

Plasma concentrations of progesterone, estradiol, corticoids and luteinizing hormone were quantified by specific radioimmunoassays that have been validated in our laboratory.

Results and Discussion

Three of 12 control gilts and 1 of 12 heat stressed gilts were pregnant at slaughter on day 32 after estrus. Pregnant control gilts had an average of 13.7±.3 corpora lutea and 11.3±1.2 embryos compared to 13 corpora lutea and 8 embryos in the one pregnant heat stressed gilt. Poor conception rates for gilts on both treatments may have been due to boar infertility rather than to cannulation and daily bleeding or chamber confinement. In preliminary trials using the same chambers and cannulation technique, normal conception rates (70 to 80 percent) were obtained.

The ambient temperatures to which the heat stressed gilts were exposed in this experiment were similar to those used by Omtvedt *et al*. (1971) which caused a reduction in conception rate and reduced embryonic survival. Water consumption during treatment was similar for heat stressed and control gilts, but feed consumption was reduced in heat stressed gilts.

Average respiratory rates were significantly greater at 8 pm for heat stressed gilts compared to control gilts (Figure 1). Respiratory rates in heat stressed gilts at 8 pm were significantly greater than the 8 am respiratory rates in stressed gilts. This difference in the 8 am and 8 pm respiratory rates of heat stressed gilts was probably due to the lower temperature the gilts were exposed to during the night.

Rectal temperatures of the heat stressed gilts (Figure 2) at 8 am were significantly greater than the temperature of control gilts at 8 am. The 8 pm temperatures in stressed gilts were greater than the 8 am temperatures in stressed gilts (40.7±.1 *vs* 39.9±.1 C, respectively). Rectal temperatures increased slightly in all gilts for the first four days of confinement then decreased during the last four days of confinement. Similar to other studies, this suggests that gilts may compensate to exposure to heat stress and rectal temperatures are reduced after several days of exposure. In our trial, there was a simple correlation of 0.45 ($P<.05$) between rectal temperature and respiratory rate of all gilts.

Plasma progesterone, estradiol, LH and corticoid concentrations on day 0 (prior to treatment) were similar for control and heat stressed gilts (Table 1). Since conception rates were reduced for both treatments, an interpretation of comparisons between one pregnant stressed gilt and three pregnant control gilts would have little meaning. Pregnant gilts were omitted from the analyses of endocrine data and comparisons between treatments were limited to non-pregnant gilts.

Plasma progesterone, corticoids, estradiol and LH were not significantly different between 8 am and 8 pm samples taken during chamber confinement. Plasma progesterone concentrations tended to be greater in stressed gilts than in control gilts during the treatment period (Figure 3). Plasma progesterone concentrations during days 9 to 13 after estrus (immediately post-treatment

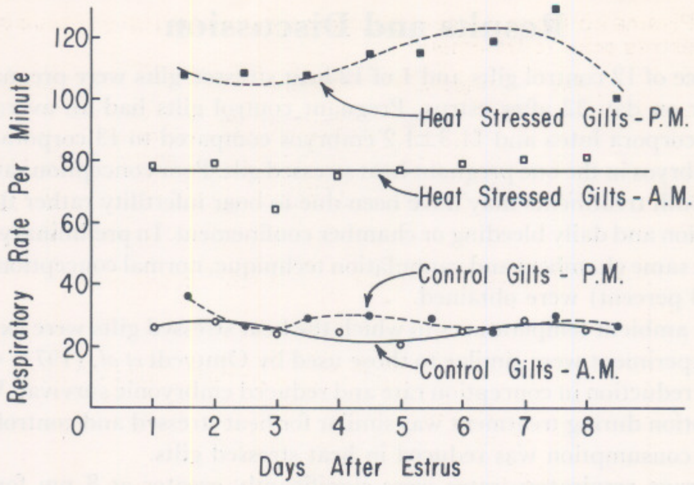

Figure 1. Respiratory rates of gilts during exposure to control or elevated ambient temperature

In the a.m., heat stressed gilts had been exposed to 32 C for the preceeding 12 hr and in the p.m. heat stressed gilts had been exposed to 35 C for the preceeding 12 hr. Control gilts were maintained at 23 C.

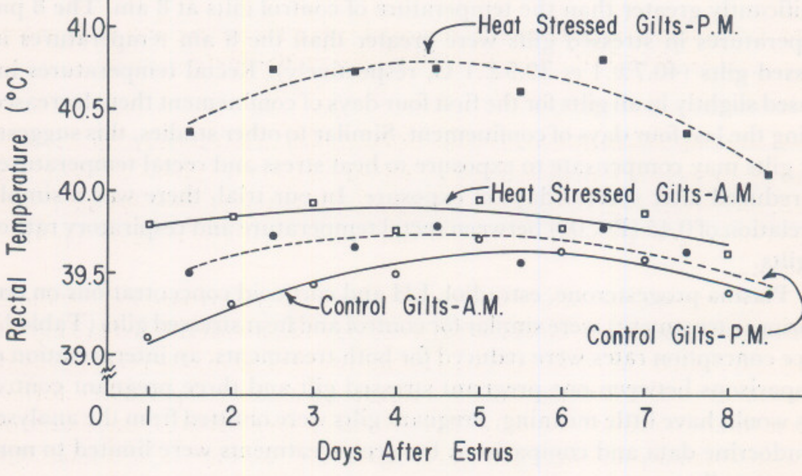

Figure 2. Rectal temperatures of gilts during exposure to control or elevated ambient temperature

In the a.m., heat stressed gilts had been exposed to 32 C for the preceeding 12 hr and in the p.m. heat stressed gilts had been exposed to 35 C for the preceeding 12 hr. Control gilts were maintained at 23 C.

Table 1. Plasma hormone concentrations in control and heat stressed gilts at estrus prior to treatment

Treatment Group	Gilts	Progesterone	Estradiol	LH	Corticoids
	(no.)	(ng/ml)	(pg/ml)	(ng/ml)	(ng/ml)
Control	12	1.0± 0.2[a]	18.1±3.7	17.4±5.1	30.4±5.7
Heat stressed	12	1.1±0.2	14.9±3.7	17.7±5.1	39.5± 5.7

[a]Mean ± S.E.

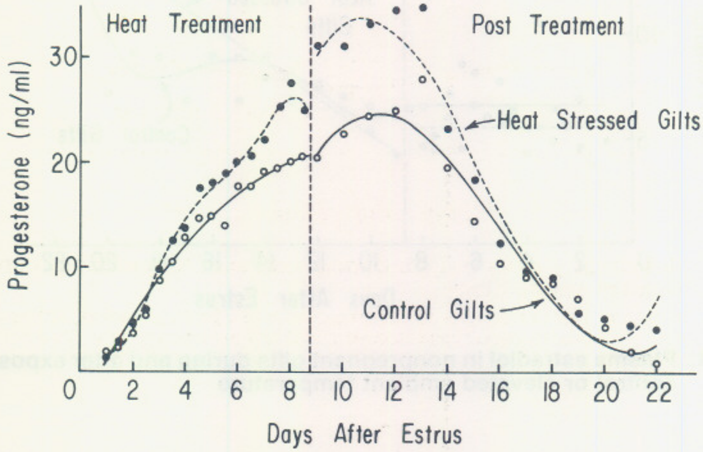

Figure 3. Plasma progesterone in nonpregnant gilts during and after exposure to control or elevated ambient temperature

period) were significantly greater in stressed gilts than in control gilts. Progesterone in control gilts increased from 1 ng/ml on day 1 to about 25 ng/ml on day 12, then decreased rapidly to about 2 ng/ml on day 21 after estrus. These changes in progesterone during the estrous cycle are similar to those reported previously.

Progesterone concentrations in heat stressed gilts increased from about 2 ng/ml on day 1 to a maximum of 34 ng/ml on day 12, then decreased to 3 ng/ml by day 20. Similar to these results, Florida workers have observed elevated plasma progestins in heifers exposed to elevated ambient temperatures during the first three days after breeding. The adrenal cortex could be the source of increased plasma progesterone in heat stressed gilts, since others have observed that gilts exposed to elevated ambient temperatures had about a two-fold increase in plasma ACTH concentrations and plasma corticoids were slightly reduced or unchanged. Similarly, injection of ACTH caused increases in both corticoids and progesterone in heifers.

Plasma estradiol concentrations were slightly reduced in heat stressed gilts during treatment, but the response was not significantly different from control gilts after chamber confinement (Figure 4). During treatment, es-

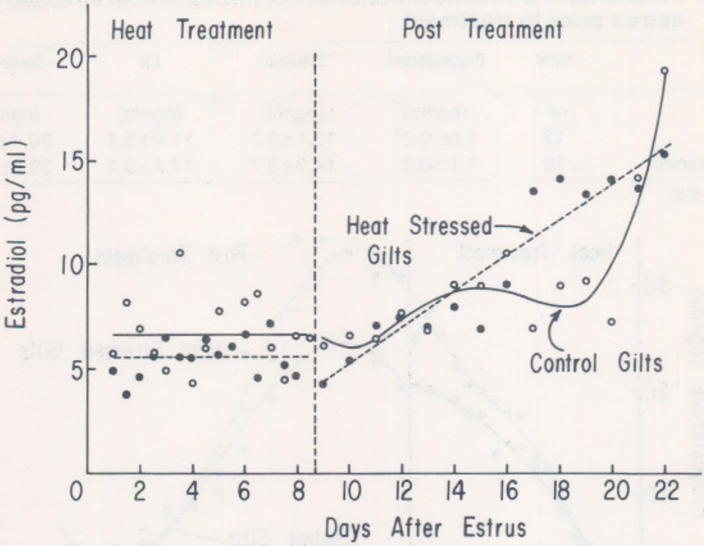

Figure 4. Plasma estradiol in nonpregnant gilts during and after exposure to control or elevated ambient temperature

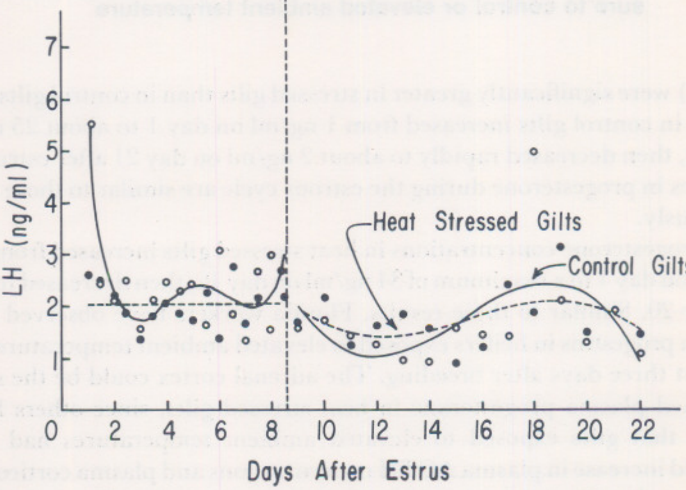

Figure 5. Plasma LH (as NIH-LH-S_{18}) in nonpregnant gilts during and after exposure to control or elevated ambient temperature

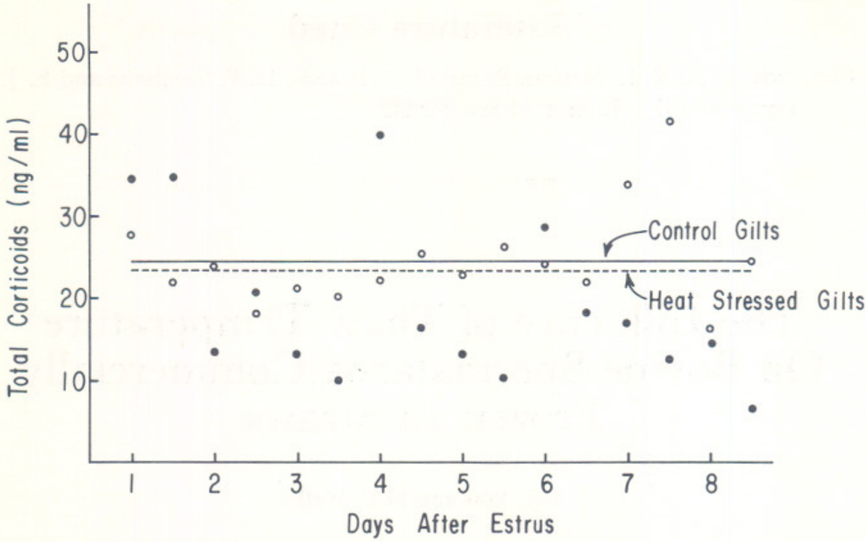

Figure 6. Plasma corticoids in nonpregnant gilts during exposure to control or elevated ambient temperature

tradiol averaged 6.7±.5 pg/ml in control gilts and 5.6±.5 pg/ml in stressed gilts. After treatment, estradiol in control gilts increased from 6 pg/ml on day 9 to 20 pg/ml on day 22, and estradiol in heat stressed gilts increased from 4 pg/ml on day 9 to 15 pg/ml on day 22. The proestrus increase in plasma estradiol which occured in control and stressed gilts was similar to increases in estrogens reported previously.

Mean plasma LH concentration (Figure 5) in control and heat stressed gilts was not different either during or after treatment. Reduced base line as well as peak plasma LH in cows exposed to elevated ambient temperature has been reported by other workers.

Plasma concentrations of total corticoids were not significantly affected by exposure of gilts to elevated ambient temperature (Figure 6). During treatment, corticoid concentrations in control gilts averaged 24.6±2.8 ng/ml compared to 23.5±4.7 ng/ml in heat stressed gilts. Average plasma corticoids for different periods ranged from 10 to 43 ng/ml.

Results of this study indicate that exposure of gilts to elevated ambient temperatures during days 1 through 8 after breeding causes increased plasma progesterone concentrations but plasma LH, estradiol and corticoids are not significantly altered. It is not known whether the increase in plasma progesterone is of sufficient magnitude to alter conception rate or embryonic survival.

Literature Cited

Omtvedt, I. T., R. E. Nelson, Ronnie L. Edwards, D. F. Stephens and E. J. Turman; 1971; J. Animal Sci. 32:312.

The Influence of Thaw Temperature On Bovine Spermatazoa Commercially Frozen In Straws

G.J. Yott and M.E. Wells

Story in Brief

Bovine semen commercially frozen and packaged in .5 ml straws, was subjected to thaw temperatures of 32 F, 68 F, 95 F and 203 F for 2 min, 1 min, 20 sec and 7 sec, respectively. Following completion of thawing, the semen was incubated at 98.6 F for either 5 min, 1 hr, 3 hr or 5 hr. The effects of these treatments were evaluated by changes in the percentage of "live" cells and changes in cell structure during the incubation periods. Faster thaw rates increased the percentages of "live" cells and cells showing no alteration of the acrosome. Of the four thaw temperatures, the 95 F/20 sec provided more live cells of desirable type than the others.

Introduction

The artificial insemination industry currently utilizes several semen packaging methods in selling semen to the public. The most recent package consists of a plastic straw, or tube, which normally contains either .3 ml or .5 ml extended semen. The straw shape and size is substantially different from the conventional glass ampule. Several problems have become apparent as breeders have used recommended ampule thawing procedures for the straw. The major problems have been poor cell viability post-thaw and variable fertility.

The straw semen packaging system was introduced before research had defined optimum handling procedures. Various straw thawing techniques are common. These include thawing in the cow, thawing between the hands, thawing in the shirt pocket, thawing in 32 F water and air thaw. These techniques obviously will result in a wide range in rate of thaw. Research has since determined that the geometric shape of the straw (surface to volume ratio) and straw freezing methods dictates particular thawing procedures. These procedures involve fast thawing rates which can be facilitated by thawing in 32 F water or 95 F water.

It appears that thawing rapidly results in improved motility and acrosome status. Thaw temperatures ranging from 40 F to 203 F have been utilized to determine optimum thawing procedures. However, the extremely rapid rates are exceptionally difficult to achieve in routine artificial insemination programs. Consequently, current recommendations by bull studs are a mixture of research findings and apparent achievable field practices.

The purpose of this study was to evaluate four thawing temperatures applied to semen frozen in plastic straws and determine the apparent usefulness of the four thaw temperatures used.

Materials and Methods

Semen frozen in .5 ml plastic straws was provided by a commercial AI Company for the study. Five different bulls were used, with eight straws provided per bull. Two straws for each bull were thawed at either 32 F, 68 F, 95 F or 203 F in a water bath for 2 min, 1 min, 20 sec and 7 sec, respectively. After thawing, straws were pooled in centrifuge tubes and placed in a constant temperature water bath at 98.6 F for incubation. At each of four incubation times, 5 min, 1 hr, 3 hr, and 5 hr, a small sample was withdrawn and evaluated for percent live cells and acrosome condition. To accomplish this, .25 ml semen was centrifuged for 2 min at 5,000 × G, washed and centrifuged for 2 successive times and re-suspended in .25 ml of 2.9 percent sodium citrate.

The evaluation for percent live cells utilized the nigrosin-eosin live-dead stain. A drop of the centrifuged semen was combined with a drop of stain for 3 min. Stained samples were smeared on glass slides, mounted and numerically coded for later evaluation. Coding was used to preclude bias or evaluator knowledge of the time the sample was taken from the incubation tube and thaw temperature used. Two hundred cells per smear were evaluated using a bright field microscope; red stained cells were considered dead while unstained cells were considered live.

The second evaluation utilized a stain that would differentiate the acrosome from the cell nucleus. A drop of the centrfuged semen was combined with a drop of the Wells-Awa acrosome stain for 3 min. Stained samples were smeared on glass slides, mounted and coded for later evaluation. Two hundred cell-counts were made on each slide to determine the percentages of acrosomes in the following categories: 1) normal cell with non-aged acrosome, 2) normal cell with aged acrosome, 3) total aged acrosome, 4) missing acrosome.

Although these four categories were determined, only the data on "percent normal non-aged acrosomes" will be utilized in this report. The remaining categories are to be used in a subsequent experiment. Non-aged acrosomes are tightly adherent to the anterior portion of the cell nucleus and have a smooth entire appearance. Deterioration of the acrosome is evidenced by ruffling, swelling or detachment and is presumed to occur either *post mortem* or immediately before cell death. (Hancock 1953, Saacke 1968).

A split plot statistical analysis of the data was performed on the "Percent Live Cells" and "Percent Normal Non-Aged Acrosomes".

Results and Discussion

There were significant effects observed in percent live cells due to the different thaw temperatures used in the study (Table 1). These effects were seen as changes in the number of cells that survived the freezing and thawing process. Fewer cells thawed at 32 F were live after 1 hr incubation than cells thawed at warmer temperatures. Incubation for five hrs increased the difference between 32 F thaw and the warmer thaw temperature. Cells thawed at any of the higher temperatures were more able to withstand incubation stress than those thawed at 32 F, suggesting that slow thawing causes damage to sperm cells. Thawing ampules in 32 F water is the accepted practice. Our data indicates that using this procedure for straws may result in somewhat reduced numbers of live cells post-thaw.

Table 2 compares the effects of thawing temperature and incubation periods on percentages of cells with normal non-aged acrosomes. After 1 hr of incubation, there were no significant differences among thaw temperatures. However, 95 F thawed cells had more normal non-aged acrosomes. Five hrs incubation produced varied changes with the cells thawed at 203 F having significantly higher percentages of non-aged acrosomes. It should be noted that populations of cells thawed at 68 F had the lowest percentage of cells with non-aged acrosomes at 1 hr incubation and had the greatest reduction in non-aged acrosomes after 5 hrs incubation. Thawing at 68 F would be approximately the rate achieved with air thaw and shirt pocket thaw procedures. Our data indicates that these procedures are inferior to either cold water or warm water thaw temperatures in maintenance of acrosome quality.

In order to further visualize thaw effects on straw packaged semen, averages over all bulls and incubation periods are shown in Table 3. The 95 F thaw resulted in the highest percent live cells and the highest percent normal non-aged acrosomes. Use of the 32 F thaw over the 95 F thaw would result in a 15.7 percent reduction in "live" cells and a 11.6 percent reduction of cells with normal non-aged acrosomes that would be available for insemination. It should also be noted that additional cell losses normally occur due to insemi-

Table 1. Mean percent "live cells" after 1 and 5 hrs of incubation*

	Thaw Temperatures			
	32 F	68 F	95 F	203 F
1 hr	57.8[a]	64.4[a]	64.7[a]	63.2[a]
5 hrs	45.6[b]	59.5[a]	60.8[a]	61.4[a]
% change	21.1	7.6	6.0	2.8

*Averages of five bulls.
[a,b]Means with different superscripts differ significantly (P<.05).

Table 2. Mean percent normal cells with non-aged acrosomes after incubation*

	Thaw Temperatures			
	32 F	68 F	95 F	203 F
1 hr	28.4[a]	25.8[a]	32.0[a]	27.4[a]
5 hrs	20.2[b]	13.0[b]	19.7[b]	23.3[a]
% change	29.0	50.0	38.0	15.0

*Averages of five bulls.
[a,b]Means with different superscripts differ significantly (P<.05).

Table 3. Percent "live" and percent normal non-aged acrosomes averaged over all incubation periods and bulls

	Thaw Temperatures			
	32 F	68 F	95 F	203 F
% "Live"	53.7	61.4	63.6	60.1
% Normal non-aged acrosomes	26.0	22.1	29.4	28.1

nation techniques and delays (from "thawed" to "inseminated"). In this case, use of the 95 F thaw would serve to provide an increased "safety factor" by the same percentages. A comparison of all thaw temperatures in Table 3 shows that thawing at 68 F was least effective in maintenance of acrosome condition. It can be concluded that use of the 95 F thaw provides more desirable cells for insemination and its use over a 32 F thaw will provide a substantial safety factor.

Literature Cited

Hancock, J.L. 1953. J. Exp. Biol. 30:50.
Saacke, R.G. 1968 J. Reprod. Fert. 16:511.

Influence of Cooling Methods on Boar Fertility with Summer Breeding

R. P. Wettemann, M. E. Wells, R. K. Johnson and R. Vencl

Story in Brief

Eighteen boars were used to evaluate the effectiveness of different boar cooling methods on fertility with summer breeding. When boars received only shade, 44.1 percent of the gilts bred were pregnant at 30 days after breeding. However, if boars were sprinkled in addition to shade or maintained in a cool chamber at 70 F, 63.9 percent and 67.8 percent, respectively, of the gilts became pregnant. Litter size of pregnant gilts was not influenced by treatment. It appears that under Oklahoma conditions, evaporative cooling from the body surface of boars is sufficient to maintain acceptable fertility during summer months and air conditioning is not necessary.

Introduction

Exposure of boars to elevated temperatures during July and August can influence their fertility through September. Thus, the number of open sows and the number of sows farrowing small litters during November, December and January could be related to the effectiveness of summer cooling methods.

We have previously determined that heat stress of boars in temperature controlled chambers results in reduced semen quality and reduced fertility (Wettemann *et al.*, 1974; Wettemann *et al.*, 1977). Eight-two percent of the gilts bred to control boars conceived, but only 59 percent of the gilts bred to heat stress boars were pregnant. When heat stressed boars were exposed to cool temperatures, semen quality improved. However, it was not until five weeks after the end of heat stress that the percentage of motile sperm was similar for stressed and control boars. Therefore, if sperm are affected in the formation stages by increased body temperature due to heat stress, the detrimental influence on semen quality is present for up to five weeks later.

During the summer of 1976, we observed that if boars were provided with only shade, respiratory rates increased and semen quality decreased. If sprinklers were available for boars in addition to shade, respiratory rates and semen quality were similar to those for boars maintained in cool chambers.

The purpose of this study was to determine the effectiveness of sprinkling boars or confinement in an air conditioned room on the maintenance of optimal fertility with summer breeding.

Materials and Methods

Eighteen boars were used in this experiment during May through October, 1977. Two Duroc, two Hampshire and two Yorkshire boars were allotted to each treatment. Six boars were housed in a temperature controlled chamber at approximately 70 F. A second group of six boars was kept in outside lots with a shade provided and a third group of six boars was kept in outside lots provided with shade and a water sprinkler from June 1 until September 15. During a three-week breeding period which started on August 11, each boar was hand mated to 5 or 6 gilts. Gilts were maintained together in a dirt lot with shade and sprinklers and were bred in the morning on the first and subsequent days of an estrus. Gilts were slaughtered at approximately 30 days after breeding and numbers of embryos and corpora lutea were determined.

Results and Discussion

The influence of the different cooling systems on boar fertility is shown in Table 1. All gilts were provided with shade and sprinklers during the study. Thus any differences in fertility are due to the effects of heat stress on the boars. When boars received only shade, 44.1 percent of the gilts bred were pregnant 30 days after breeding. If boars were sprinkled in addition to shade, 63.9 percent of the gilts became pregnant. Maintaining boars in a cool chamber during the hot summer resulted in no significant improvement in fertility compared to boars with both shade and sprinklers. Litter size for the pregnant gilts at 30 days after breeding was not significantly influenced by treatment.

The fertility of the boars provided with both shade and sprinklers and the cool chamber boars was about 10 to 15 percent less than we normally observe when breeding during cooler months of the year. This reduction in fertility could be related to heat stress of the gilts or to sexual rest of the boars. The boars were not used for breeding nor was semen collected during the six weeks preceding the breeding season. Semen quality in most males is reduced after a period of sexual rest.

All boars are not affected the same by heat stress. Heat stress may completely inhibit sperm production in some boars but only cause slight reductions in semen quality in others. In Table 2, boars are ranked into fertility groups. Five of the six boars receiving only shade settled 50 percent or less of the gilts bred. Whereas, only two of the boars with shade and sprinklers and one boar maintained in a cool chamber settled 50 percent or less of the gilts that they were mated with. None of the shade treatment boars settled as many as 75 percent of the gilts with which they were mated. However, two of the boars with shade and sprinklers and three of the boars in a cool chamber settled more than 75 percent of the gilts that they were mated with.

Table 1. Fertility of gilts bred during August 1977 to boars maintained with shade, shade and sprinklers or in a cool chamber during the summer

Treatment	No of boars	No of gilts bred	Gilts pregnant at 30 days		
			No	Percent	No of embryos
Shade	6	34	15	44.1	11.8±.6
Shade and sprinkler	6	36	23	63.9	10.6±.5
Cool chamber	6	31	21	67.8	10.4±.7

Table 2. Fertility rank of individual boars maintained with shade, shade and sprinklers or in a cool chamber during the summer of 1977

Treatment	Number of boars that settled the following percentage of the gilts bred		
	≤50%	51-74%	≥75%
Shade	5	1	0
Shade and sprinklers	2	2	2
Cool chamber	1	2	3

Based on the trials conducted during 1976 and 1977, it appears that under Oklahoma conditions, evaporative cooling from the body surface of boars is sufficient to maintain acceptable fertility during summer months and air conditioning is not necessary. When air temperature gets above 80 F, if boars are provided with sprinklers along with shade, this should be sufficient to prevent heat stress.

Literature Cited

Wettemann, R. P., M. E. Wells, I. T. Omtvedt, C. E. Pope, E. J. Turman, G.W.A. Mahoney and T.W. Williams. 1974. Oklahoma Agr. Exp. Stat. MP-92:204.

Wettemann, R. P., M. E. Wells, L. W. Brock, R. K. Johnson, R. Harp and R. Vencl. 1977. Oklahoma Agr. Exp. Stat. MP-101:152.

The Influence of Radiant Heat Load And Temperature Stress on Bull Growth and Fertility

D. C. Meyerhoeffer and S. W. Coleman

Story in Brief

Four yearling bulls (15-18 mo age) were allotted to .4 ha bermudagrass pastures. Two pastures had shades available to the animals at all times. Daily gains were greater .56 vs .44 kg/day for the animals with shade. There were no apparent differences in volume of semen; however, motility of cells, percent live and normal were lowered while aged, abnormal and abnormal non-aged cells were increased in animals without access to shade. There were interactions between weeks and shade availability. Temperatures varied from a low of 26.7 C to a high of 41.7 C with 55 days in which the daily high was above 32.2 C. Results indicate that animals with shade may be better *doers* and maintain higher levels of fertility. Additional shade studies are indicated as necessary.

Introduction

Reproductive efficiency of the male is lowered when exposed to high environmental temperatures. Radiation from the sun during the summer months may reach levels to adversely influence reproductive capacity. Sperm formation and maturation is a continuous process requiring from six to eight weeks in the bovine. Any damage to cells during this process will affect fertility for several weeks.

The purpose of this pilot study was to measure the effects of shade on growth and semen quality of young bulls exposed to summer temperatures.

Experimental Design

Four yearling angus bulls weighing 342 kg were each allotted to .4 ha bermudagrass pastures. Two pastures had shades constructed of pipe and covered with baled straw. The remaining pastures had no shade other than some tall grass along fence lines. A split plot in time with two treatments was used for this study. Animals were rotated among the pastures at three week intervals for the first 12 weeks and remained on the same pasture the last 6 weeks. Abundant forage was available in all pastures during the entire trial.

In cooperation with USDA, Science and Education Administration, Southern Region.

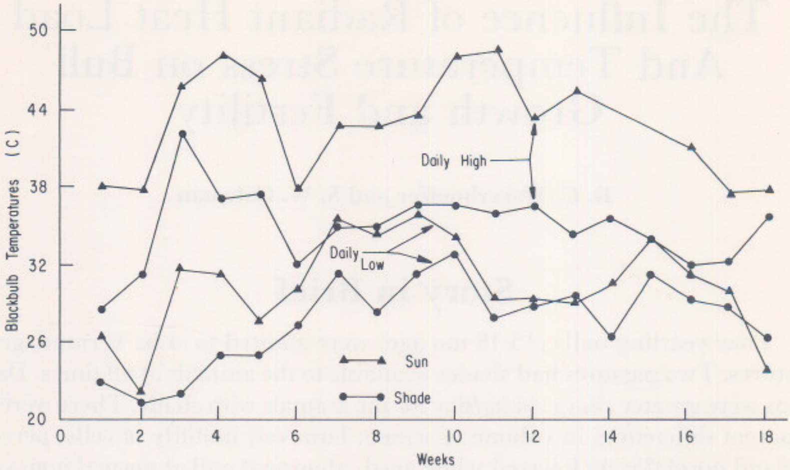

Figure 1. Weekly variation in blackbulb temperatures

The bulls were electroejaculated each week for semen evaluation and weighed at three week intervals. Ambient and blackbulb temperatures in and out of shade were recorded at 2-3 hr intervals daily from 8 am to 5 pm. Continuous ambient temperature, relative humidity and barometric pressure were also recorded near the experimental site.

Results and Discussion

Blackbulb (BB) temperatures (a black sphere, 15.24 cm, with thermometer inserted to its center) are accepted as a measure of sun irradiation effects and heat load. Figure 1 shows a comparison of BB temperatures in the sun and the shade with highs and lows for each week. Daily high blackbulb temperature averaged 42.8 C in the sun and 35.0 C in the shade (significant, $P=.0271$). Weeks and shade × week interaction were also significant ($P<.01$). Daily low BB in shade was also lower than in the sun ($P=.087$) and the interactions between shade × week were again significant ($P<.01$). Daily high ambient temperature averaged 32.9 C in the sun and 31.7 C in the shade ($P=.053$) with peaks much higher as shown in Figure 2.

Daily gains were .56 kg/day *vs* .44 kg/day for animals in shade and no shade pastures respectively. No difference was found in volume of semen collected, but motility steadily decreased reaching a low of 45 percent at 12 weeks for animals without access to shade compared to 82 percent for animals with shade. Figure 3 shows the difference in motility and percent abnormal cells over time. The average motility for bulls with shade was 84 percent *vs* 66.9 percent for those without shade. Abnormal cells were higher during the same time periods that motility was lowest.

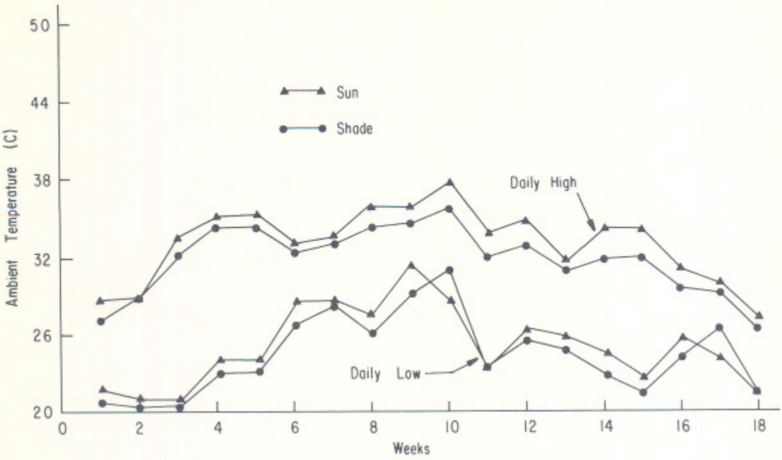

Figure 2. Weekly variation in ambient temperature

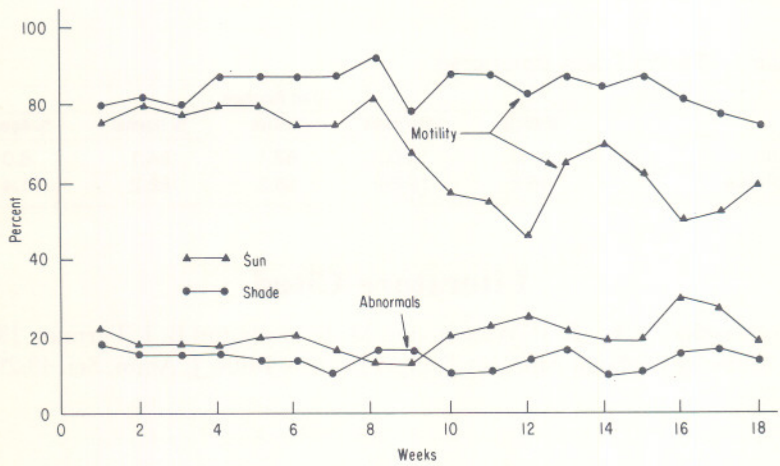

Figure 3. Weekly variation in percent motility and percent abnormal cells

Figure 4 shows the variation in abnormal non-aged and aged cells as affected by availability of shade. Abnormal non-aged cells averaged 25.5 percent in the sun and 13.4 percent in the shade.

Table 1 lists averages for traits from animals with and without shade.

Though significant differences due to availability of shade were not found with the traits which affect motility, the numerical averages indicate a potential biological importance. As illustrated with artificial environments (Meyerhoeffer *et al*., 1976), approximately 6-8 weeks were required for high temperatures to influence sperm production (Figures 1, 3 and 4).

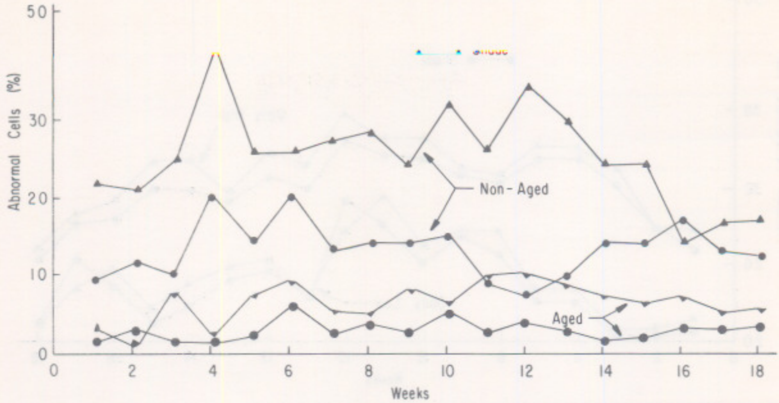

Figure 4. Weekly percent variability of abnormal aged and non-aged cells

Table 1. Semen Traits Compared

	Trait Average				
	Motility	Abnormals	% Live	% Normal	% Aged
Shade	84.0	14.05	82.1	84.1	6.0
No shade	66.9	19.84	68.2	68.2	11.4

Literature Cited

Meyerhoeffer, D. C., R. P. Wettemann, M. E. Wells and E. J. Turman. 1976. Effect of Evelated Ambient Temperature on Bulls. J. Anim. Sci. 43:297.

Summary Reports
DAIRY PRODUCTS

A Rapid Screening Test for Hydrogen Peroxide Production by Lactobacilli

D. R. Martin and S. E. Gilliland

A dilution of a broth culture of *Lactobacillus lactis* was evenly spread with a sterile hockey stick on the surface of 15 ml of MRS lactobacilli agar (Difco Laboratories) containing 0.1 ml of peroxidase (0.2 mg/ml) and 0.1 ml of o-tolidine (20 mg/ml). Peroxidase in the presence of the chromogen o-tolidine reacts with hydrogen peroxide to produce a color change in the chromogen. It was assumed that any peroxide metabolically produced by the lactobacilli during colony formation on the agar medium described above would produce similar color changes. The plates were incubated 24 hr at 37 C. Three colony types were selected for isolation from the plates; those with no color zones surrounding them and those with intermediate and large brown zones.

The isolated cultures of lactobacilli were tested for the ability to produce peroxide in refrigerated sterile 10 percent NFMS (Gilliland and Speck, 1975). The cells in 10 ml of MRS broth were harvested by centrifuging in sterile centrifuge tubes at 12,000 x g for 10 min at 2 C. The pellet from each was resuspended in 5 ml of cold sterile 10 percent NFMS and transferred to a 50 ml Erlenmeyer flask containing 20 ml of cold sterile 10 percent NFMS. The flasks containing the samples were incubated for 22 hr at 5 C on a platform shaker to ensure continuous mixing during incubation. Hydrogen peroxide was measured by an enzymatic method described by Gilliland (1969). The number of viable organisms in the test cultures were determined at 0 hr and 22 hr by plating on MRS agar.

More peroxide was produced by the cultures isolated from colonies which produced the larger zones on the "peroxidase agar" than in those with smaller zones. The numbers of viable lactobacilli remained constant over the 22 hr period at 5 C. *L. lactis* cultures do not grow at 5 C and thus do not produce appreciable acid. The peroxide produced by the lactobacilli added to refrigerated foods can inhibit psychrotrophic spoilage organisms (Gilliland and

Speck, 1975). The "peroxidase agar" test described herein could be used as a rapid screening test for selecting cultures for preparing frozen concentrated cultures to be used for such control of psychrotrophic microorganisms in refrigerated food.

Literature Cited

Gilliland, S. E. 1969. Enzymatic determination of residual hydrogen peroxide in milk. J. Dairy Sci. 52:321.

Gilliland, S. E. and M. L. Speck. 1975. Inhibition of psychrotrophic bacteria by lactobacilli and pediococci in nonfermented refrigerated foods. J. Food Sci. 40:903.

MEAT and CARCASS EVALUATION

Conditions Associated With Net K^{40} Counting Using Animal Phantoms

D. D. Johnson, L. E. Walters, R. R. Frahm,
R. D. Morrison and B. Lambert

The principle of K^{40} whole-body counting is currently being used at the Oklahoma Agricultural Experiment Station to evaluate both beef cattle and market weight swine. Previous studies at this station have shown that this method can be used to predict the lean body mass in both species, to within ± 9 lb of fat free lean for beef cattle and ± 2.5 lb of fat free lean for swine. These studies emphasized the need to identify and adjust for sources of variation in K^{40} counting where possible. Also these experiments brought to light other sources of variation not heretofore identified for which adjustments should be made in order to maximize the accuracy of the whole-body counting principle, especially where differences in live weight occur.

Several techniques to improve the relationship between net K^{40} count and lean muscle mass in live animals are presently being used. These techniques include washing the animal prior to counting for the purpose of removing fallout residue and foreign material high in potassium, in an effort to reduce animal contamination. Secondly, animals are held off feed for 24 hr prior to counting to adjust for fill. In addition, instrument fluctuations are continuously monitored by the use of a standard (known) reference source of radiation. This reference source is a container filled with potassium chloride which has been used for this purpose for an extended period of time.

Two other variables which until recently have been most difficult to identify and adjust for are (1) self-absorption and (2) background depression. *Self-absorption*, which is the scattering and absorption of radiation originating from the object being counted has been shown to be primarily associated with the weight (mass) of the animal. Such a phenomenon has been demonstrated in non-living masses called *phantoms* which are used to simulate animals. This condition occurs as the result of the inability of a certain part of the radiation originating within the animal or object to be counted, thus the term self-absorption. For example, as animals increase in weight, it appears that some of the radiation may travel a distance great enough to increase its chance of being absorbed by body tissues and thus is unable to reach a detector and to be considered in net K^{40} count.

Background depression is attributed to the absorption of environmental radiation by the object being counted. It is believed that self-absorption and background depression contribute to an underestimation of lean body mass in larger, heavier animals.

A study was undertaken in an effort to more thoroughly understand and identify the effects of self-absorption and background depression in the K^{40} whole-body counting procedure by the use of animal phantoms. These animal phantoms were constructed of one gallon and one quart plastic containers which were filled with a water solution of potassium and sodium chloride. The dimensions of each phantom were selected to approximate the length, width, and height dimensions of similar weight bred gilts involved in a companion nutrition study. Five phantoms: 200, 260, 320, 380 and 440 lb respectively were constructed by arranging the above mentioned containers in multiple layers placed on a mobile dolly, resembling the general shape of animals of these corresponding weights.

Each of these five phantoms weights were constructed using three concentrations of potassium, designated "high", "medium" and "low". The medium concentration was prepared to approximate the amount of potassium in the body of an "average" or "typical" bred gilt, where as the high concentration more closely approximated the amount of potassium expected in a very lean, heavily muscled bred gilt, and the low concentration approximated the amount of potassium in a fatter, lighter muscled bred gilt. The desired density of the solution (1.04 g/ml) was prepared to correspond with that of a typical gilt and was accomplished by adding specific amounts of sodium chloride in accordance with the concentration of potassium in the phantoms.

Mean counting efficiencies for each concentration and each weight are presented in Figure 1. These values represent the average of eight counts for each weight and each potassium concentration. Counting efficiency was calculated by dividing the mean net count of the phantom by the total counts possible from the known quantity of potassium in the phantom. These data indicate that as weight increases, counting efficiency decreases. This suggests that as the animals' weight increases there is a tendency to underestimate the amount of potassium in the animals' body by the K^{40} counter and therefore to underestimate the lean body mass of the animal. From these data prediction equations will be developed which will adjust for this decrease in counting efficiency.

These experiments using phantoms ranging in weight from 200 to 440 lb constitute the forerunner to another study currently being initiated using heavier weight phantoms corresponding in weight with yearling beef bulls

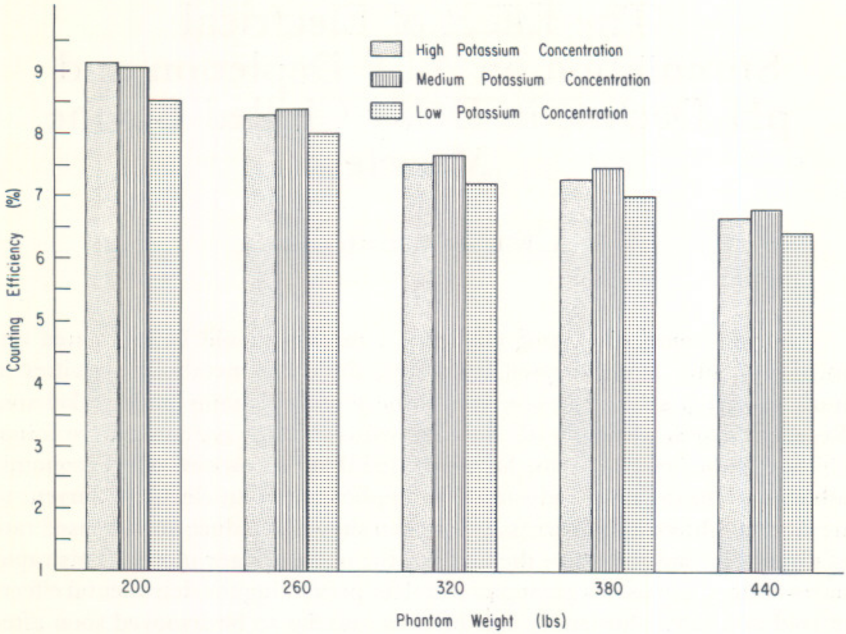

Figure 1. The relationship between counting efficiency and phantom weight at three potassium concentrations

ranging from 900 to 1300 lb. The prediction equation currently in use for the evaluation of beef bulls was developed from bulls weighing under 1000 lb. With new and meaningful information relating to the effects of weight on counting efficiency, it will be possible to more accurately evaluate beef bulls for lean content whose weights are heavier than those from which the present prediction equation was developed.

The Effect of Electrical Stimulation on ATP Depletion and pH Decline in Delay Chilled Bovine Muscle

P. A. Will and R. L. Henrickson

For optimum processing efficiency a carcass should be fabricated immediately after being dressed. However, there are metabolic activities in muscles which should proceed while the muscle remains on the skeleton. Recent research dealing with the removal of muscle systems before initial chilling of the bovine carcass has suggested that this process offers economic advantages to the meat industry. The application of an electrical current to freshly slaughtered beef carcasses has been shown to induce an increased rate of glycolysis, and to reduce the time for the onset of rigor mortis. This rapid onset of rigor mortis has great protential for preventing the detrimental effects of cold and thaw shortening and permits muscles to be removed soon after slaughter.

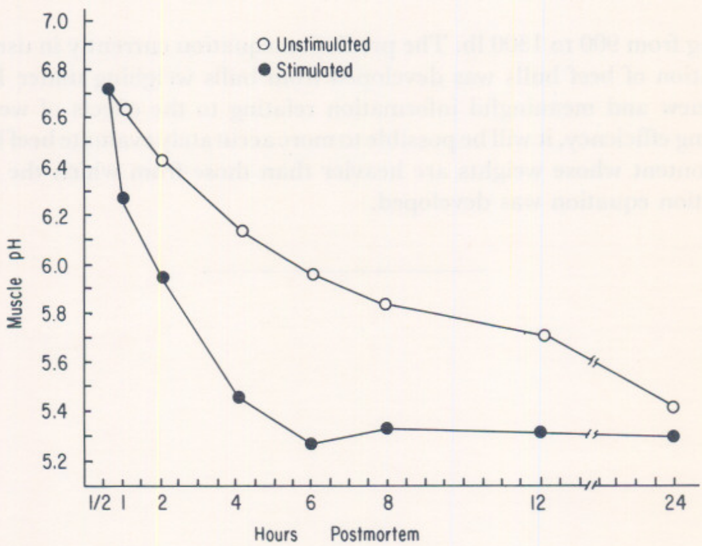

Figure 1. Effect of electrical stimulation on pH decline

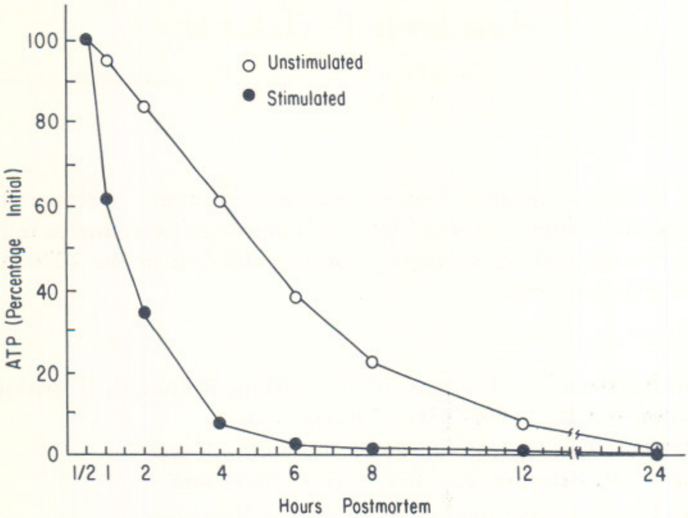

Figure 2. Effect of electrical stimulation on ATP depletion

This study was undertaken to assess the effectiveness of electrical stimulation as a means of speeding postmortem metabolism as measured by ATP (adenosine triphosphate) depletion and pH decline in delay chilled bovine carcasses.

Six animals of similar weight and age were used in this study. Electrical stimulation was initiated 30 min post mortem. The stimulated side received a square wave pulse of 300V., 400c/s with a duration of 0.5 msec and a current of 1.9 amps for a period of 15 min, while the control side received no electrical stimulus. ATP and pH measurements were taken at eight time periods. (0.5, 1.0, 2.0, 4.0, 6.0, 8.0, 12.0, 24.0 hr) postmortem. Muscles from the electrically stimulated sides of beef exhibited significantly faster reductions of ATP and pH than unstimulated controls (Figures 1 and 2).

Research Personnel

This is a listing of project leaders, graduate students, technicians and herdsmen in the Animal Science Department and other personnel as indicated who have co-authored the research reports published in the 1978 Animal Science Research Report.

Ackerson, Barbara A. - Laboratory Technician, Ruminant Nutrition
Adams, Glenden D. - Dairy Herd Management
Adams, Robert L. - Former Graduate Assistant, Meats
Armbruster, Dr. Stephen L. - Beef Cattle, Extension
Ball, Roy A. - Graduate Assistant, Ruminant Nutrition
Barnes, Kent C. - Former Graduate Assistant, Ruminant Nutrition
Barto, Dr. Paul B. - Department of Veterinary Parasitology, Microbiology and Public Health; Microbiology
Belcher, Carla G. - Graduate Assistant, Beef Cattle Breeding
Belcher, Danny R. - Graduate Assistant, Beef Cattle Breeding
Bennett, Edward N. - Herdsman, Beef Cattle Breeding
Bostian, Marianne L. - Graduate Assistant, Dairy Products
Boyd, Michael E. - Former Graduate Assistant, Beef Cattle Breeding
Brock, Larry W. - Former Graduate Assistant, Reproductive Physiology
Burkitt, Robert F. - Former Graduate Assistant, Poultry Nutrition
Burnett, Gary - Former Undergraduate Student Employee, Ruminant Nutrition
Bush, Dr. Linville J. - Dairy Nutrition
Coleman, Dr. Samuel W. - USDA, SEA, Southwestern Livestock and Forage Station, El Reno, Ruminant Nutrition
Crosthwait, Gary L. - Graduate Assistant, Ruminant Nutrition
Croy, Dr. Lavoy - Agronomy Department, Crop Physiology
Dvorak, Michael J. - Herdsman, Ruminant Nutrition
Dzakuma, Jackson - Graduate Student, Sheep Breeding and Management
Escoubas, J. Roy - Former Graduate Assistant, Meats
Felber, Roger V. - Former Graduate Assistant, Meats
Fent, Roger W. - Herdsman Supervisor, Reproductive Physiology
Ferrell, Eldon L. - Feedmill Operator
Fields, John E. - Shepherd, Sheep Breeding and Management
Forero, Orlando - Graduate Student, Ruminant Nutrition
Frahm, Dr. Richard R. - Beef Cattle Breeding

Frost, Denzil F. - Graduate Assistant, Ruminant Nutrition
Gill, Dr. Donald R. - Ruminant Nutrition, Extension
Gilliland, Dr. Stanley E. - Dairy Products
Guenther, Dr. John J. - Meats
Hammond, Robert W. - Research Technician, Agronomy
Henrickson, Dr. Robert L. - Meats
Herriman, Roger D. - Graduate Assistant, Sheep Breeding and Management
Hibberd, Charles A. - Graduate Assistant, Ruminant Nutrition
Hintz, Dr. Richard L. - System Analysis and Animal Breeding
Horn, Dr. Floyd P. - Location and Research Leader, USDA, SEA, Southwestern Livestock and Forage Research Station, El Reno, Ruminant Nutrition
Horn, Dr. Gerald W. - Ruminant Nutrition
Hoskins, Daniel T. - Herdsman Supervisor, Ruminant Nutrition
Hutchens, Leslie - Graduate Assistant, Swine Breeding
Jafri, Saghir A. - Graduate Student, Dairy Management
Johnson, A. Bruce - Graduate Assistant, Ruminant Nutrition
Johnson, D. Dwain - Graduate Assistant, Meats
Johnson, Dr. Rodger K. - Swine Breeding
Kimbrell, Leroy - Meat Laboratory Supervisor
Knori, Leon - Superintendent, Lake Carl Blackwell Research Range
Kreider, David L. - Former Graduate Assistant, Reproductive Physiology
Lambert, Bruce W. - Laboratory Technician, Animal Evaluation
Leme, Paulo R. - Graduate Student, Ruminant Nutrition
Lemenager, Ron - Former Graduate Assistant, Ruminant Nutrition
Lusby, Dr. Keith S. - Ruminant Nutrition
Mader, Terry L. - Laboratory Supervisor, Ruminant Nutriton
MaGee, John G. - Herdsman, Reproductive Physiology
Martin, David R. - Graduate Assistant, Dairy Products
Martin, Dr. Jerry J. - Chairman Division of Agriculture, Panhandle State University, Goodwell, Oklahoma
Maxwell, Dr. Charles V. - Swine Nutrition
Myerhoeffer, Dr. David - USDA, SEA, Southwestern Livestock and Forage Research Station, El Reno, Reproductive Physiology
Mizwicki, Keith L. - Graduate Assistant, Ruminant Nutrition
Morrison, Dr. Robert D. - Statistics Department
Murray, Eugene E. - Animal Care Supervisor, Poultry Nutrition
McMurphy, Dr. Wilfred E. - Agronomy Department, Pasture and Forage Management
Noble, Robert D. -- Former Graduate Assistant, Meats
Novotny, Kris K. - Laboratory Technician, Meats

Owens, Dr. Frederic N. - Ruminant Nutrition
Poling, Kenneth B. - Animal Care Supervisor, Ruminant Nutrition
Powell, Dr. Jeff - Agronomy Department, Range Science
Raccach, Dr. Moshe - Research Associate, Meats
Ridenour, Larry D. - Former Graduate Assistant, Ruminant Nutrition
Rider, Dr. Allen R. - Agricultural Engineering, Crop Processing and Materials Handling
Rust, Steven R. - Graduate Assistant, Ruminant Nutrition
Schemm, Rodney L. - Former Graduate Assistant, Ruminant Nutrition
Schooley, James D. - Herdsman, Swine Breeding
Scott, Melford L. - Extension Livestock Specialist, Southwest District
Shockey, Beverly J. - Laboratory Supervisor, Ruminant Nutrition
Solaiman, Sandra G. - Graduate Student, Ruminant Nutrition
Stevens, Vernon L. - Extension Livestock Specialist, Northwest District
Stout, Dr. Jack D. - Dairy Management, Extension
Thayer, Dr. Rollin H. - Poultry Nutrition
Thomas, David L. - Former Graduate Assistant,Sheep Breeding and Management
Thornton, Dr. John H. - Former Research Associate, Ruminant Nutrition
Totusek, Dr. Robert - Head, Animal Science Department, Ruminant Nutrition
Turman, Dr. E. J. - Reproductive Physiology
Vencl, Rex - Herdsman, Swine Breeding
Wagner, Dr. Donald G. - Ruminant Nutrition
Walker, Dr. Odell L. - Department of Agricultural Economics
Walters, Dr. Lowell E. - Meats
Wells, Dr. Milton E. - Reproductive Physiology
Welty, Stephen D. - Former Herdsman, Swine Breeding
Wettemann, Dr. Robert P. - Reproductive Physiology
Whiteman, Dr. Joe V. - Sheep Breeding and Management
Will, Paul A. - Graduate Assistant, Meats
Williams, Dr. Don E. - Manager, Hitch Feedlot, Guymon, Oklahoma
Wilson, Bob R. - Graduate Student, Ruminant Nutrition
Wilson, Eldon R. - Graduate Assistant, Swine Breeding
Wyatt, Dr. Roger D. - Ruminant Nutrition
Yott, George J. - Graduate Student, Reproductive Physiology

Acknowledgements

Many companies, organizations, and individuals have contributed money, materials, and/or services to aid Animal Science Research, Teaching or Extension Programs as indicated below. These contributions were instrumental in furthering the various programs of the Department and are gratefully acknowledged.

On campus, the cooperation of staff in the College of Veterinary Medicine, and the Departments of Biochemistry, Agronomy, Agricultural Economics, Agricultural Engineering, Microbiology, Entomology and Statistics was important in the design and implementation of several projects.

Studies at the Southwestern Livestock and Forage Research Station at El Reno, Oklahoma, were conducted in cooperation with U.S.D.A., Science and Education Administration, Southern Region, Texas-Oklahoma Areas. The assistance and counsel of Dr. M.B. Gould, present Superintendent of the Station, is gratefully acknowledged. Several studies at Stillwater were part of regional research projects.

The following is a listing of those who have contributed to the various programs of the Animal Science Department during the preceding year.

Abbott Laboratories, North Chicago, Illinois, for hormones for physiology research.

American Breeders Service, De Forest, Wisconsin for providing bovine semen frozen in 0.5 ml straws.

American Colloid Co., Skokie, Illinois, for materials for nutritional evaluation.

American Lecithin Co., Atlanta, Georgia, for supplying soybean lecithin for research on lipid metabolism in laying hens.

Associated Milk Producers, Inc. (Oklahoma Division) Oklahoma City, Oklahoma, for financial assistance of dairy management research.

Dr. Donald J. Banks, Agronomy Department, for assistance with and use of Coulter Counter Equipment.

Brown Swiss Enterprises, Inc., for financial assistance in beef cattle breeding research.

Calcium Carbonate Co., Quincy, Illinois, for materials for nutritional evaluation.

Celanese Chemical Co., Corpus Christi, Texas, for materials for dairy products research.

Church and Dwight Co., Inc., Piscataway, New Jersey, for materials for nutritional evaluation and a grant-in-aid.

Clinton Corn Processing Co., Clinton, Iowa, for supplying corn oil for research on lipid metabolism in laying hens and turkeys.

Cooperative States Research Service for a research grant to study postpartum reproduction in cattle.

Cornett Packing Co., Oklahoma City, Oklahoma, for assistance in obtaining data on animals slaughtered for extension programs.

Mr. Harry Darby, Kansas City, Kansas for the donation of Hereford cows for use in range cow research programs in nutrition, reproduction and management.

Degussa Chemicals, Inc., Frankfort, Germany, for support and materials for beef cattle research.

Delst Chemical Co., Anaheim, California, for materials for nutritional evaluation.

Diamond V. Mills, Inc., Cedar Rapids, Iowa, for funds and materials to support research with caged turkey breeders.

Elanco Products Company, Division of Eli Lilly and Company, Greenfield, Indiana, for providing drugs, monensin and a financial grant to support monensin research with range cows, feedlot cattle, and wheat pasture stockers.

Farmland Industries, Inc., Kansas City, Missouri, for providing financial support for research in meat processing, dairy, and beef cattle nutrition.

Farmland Industries, Inc., for providing soybean oil meal from their plant at Van Buren, Arkansas for research in dairy nutrition.

Farr Better Feeds, Guymon, Oklahoma, for providing feed ingredients for nutrition research.

Grain Utilization Research, Guymon, Oklahoma, for assistance in beef cattle nutrition research.

Harris Meat Company, Oklahoma City, Oklahoma, for assistance in obtaining data on arrivals slaughtered for extension programs.

Mr. Leslie Hinds, Dill City, Oklahoma, for providing cattle, wheat pasture, and labor for monensin - wheat pasture stocker field trials.

Hitch Feedlots, Guymon, Oklahoma, for funds, feed and cattle to support studies in beef cattle nutrition research.

IMC Chemical Group Inc., Terre Haute, Indiana, for growth promoting implants.

Lonza Inc., Fair Lawn, New Jersey, for assistance in beef cattle nutrition research.

Jack Marsh Distributors, Inc., Oklahoma City, Oklahoma for use of a Hollymatic Mechanical Tenderizer.

Master Feeders, Inc., Hooker, Oklahoma, for feed and support of studies in beef cattle nutrition research.

Master Feeders II, Inc., Garden City, Kansas, for feed and support of studies in beef cattle nutrition research.

Master Veterinary Service, Guymon, Oklahoma, for funds to support research on grain processing.

Merveldt Enterprises, Okarche, Oklahoma, for materials for nutritional evaluation.

Min-Ad Inc., Greeley, Colorado, for materials for nutritional evaluation.

National Livestock Commission Company, Oklahoma City, Oklahoma, for purchasing beef cattle for research products.

NIPAK Chemical Company, Pryor, Oklahoma, for supplying urea and a financial grant for range cow research.

North American Limousin Foundation, Denver, Colorado, for financial support and semen for use in the beef cattle genetics research program.

Occidental Chemical Company, Houston, Texas, for making a phosphorus supplement available for research with turkey breeder hens in cages.

Oklahoma Animal Disease Diagnostic Laboratory for diagnostic service in connection with poultry research projects.

Oklahoma Dairy Herd Improvement Association, Inc., for butterfat test of milk samples from research project animals.

Oklahoma Feed Manufacturers Association, for providing assistance with the graduate research scholarship and the undergraduate scholarship program.

Oklahoma Medical Research Foundation, Oklahoma City, Oklahoma, for assistance in lipid metabolism studies with chickens and turkeys.

Oklahoma Pork Commission, for a research grant to study the prevalence of internal parasites in Oklahoma swine.

Oklahoma Purebred Dairy Cattle Association for scholarships and Dairy Judging Team support.

Oklahoma Sheep Commission for grant to support predator control demonstration.

Ralph's Packing Co., Perkins, Oklahoma, for assistance in obtaining data on animals slaughtered for extension, research and teaching programs.

Schwab and Co., Oklahoma City, Oklahoma, for assistance in obtaining data on animals slaughtered for extension programs.

Snell Systems, Inc., San Antonio, Texas, for energizer (loan) and wire to construct a predator fence.

Texas A & M University, College of Veterinary Medicine, Department of Veterinary Microbiology, College Station, Texas, for blood testing turkey breeder hens.

Tyson Foods, Springdale, Arkansas, for supplying feather meal for research with range cows.

USDA Science and Education Administration for a research contract to study the treatment of cheese whey to reduce pollution.

U.S. Energy Research and Development Administration, for support of research on "Energy Conservation in the Meat Processing Industry".

Mr. Lorn Wehrenberg, Garber, Oklahoma, for providing cattle, wheat pasture, and labor for monensin - wheat pasture stocker field trials.

Wilson and Company, Oklahoma City, Oklahoma, for cooperation in obtaining carcass data on animals slaughtered for research and extension programs.
