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Zelpha B. Johnson and
D. Wayne Kellogg,
Editors

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ARKANSAS ANIMAL SCIENCE DEPARTMENT REPORT 1999

Edited by

Zelpha B. Johnson
Research Assistant Professor

and

D. Wayne Kellogg
Professor

Department of Animal Science
University of Arkansas

Arkansas Agricultural Experiment Station
Fayetteville, Arkansas 72701

INTRODUCTION

The faculty and staff of the Animal Science Program are pleased to present the second edition of Arkansas Animal Science. We hope you will find the reports of the research, teaching, and extension programs useful in your research, educational or production programs.

The key event this year was the long-awaited dedication of the Pauline Whitaker Animal Science Center on April 17, 1999. Along with a major gift from the Pauline Whitaker family, other major contributions were made from the Arkansas Cattlemen's Association, Arkansas Pork Producers Association and the Arkansas Farm Bureau Federation, including contributions from county Farm Bureaus, county Cattlemen's Associations, breed associations and the U of A Division of Agriculture. A significant number of private gifts were contributed by friends, alumni, faculty, and staff.

The main building covers over 45,000 square feet, including the arena with 750 chairback seats and a 25,000 square foot arena floor. Three formal classrooms and a large reception area with adjoining kitchen and conference room complete the building. An animal preparation and holding barn plus pastures are adjacent to the building. The Dorothy E. King Equine Pavilion, scheduled for construction this fall, will provide an outdoor arena and specialized facilities for horses adjacent to the Pauline Whitaker Animal Science Center. The facility has already had tremendous impacts on our ability to recruit students and provide programming to our clientele.

In addition to teaching and research activities, the Animal Science Program offers a number of educational programs for the Arkansas livestock industries. Livestock producers, who are applying extension recommended management practices, have improved livestock efficiency. These programs include, but are not limited to, the Arkansas Beef Improvement Program, beef quality assurance, bull evaluation, dairy cattle, horses, grazing schools, steer feedout, pasture management, and 4-H livestock projects. These programs are delivered by Animal Science and County Extension Faculty.

Sincerely,

Keith Lusby
Department Head
Fayetteville

Tom Troxel
Section Leader
Little Rock

INTERPRETING STATISTICS

Scientists use statistics as a tool to determine what differences among treatments are real (and therefore biologically meaningful) and what differences are probably due to random occurrence (chance) or some other factors not related to the treatment.

Most data will be presented as means or averages of a specific group (usually the treatment). Statements of probability that treatment means differ will be found in most papers in this publication, in tables as well as in the text. These will look like ($P < .05$); ($P < .01$); or ($P < .001$) and mean that the probability (P) that any two treatment means differ entirely due to chance is less than 5, 1, or .1%, respectively. Using the example of $P < .05$, there is less than a 5% chance that the differences between the two treatment averages are really the same. Statistical differences among means are often indicated in tables by use of superscript letters. Treatments with the same letter are not different, while treatments with no common letters are. Another way to report means is as mean $\pm$ standard error (e.g. 9.1 ± 1.2). The standard error of the mean (designated SE or SEM) is a measure of how much variation is present in the data – the larger the SE, the more variation. If the difference between two means is less than two times the SE, then the treatments are usually not statistically different from one another. Another estimate of the amount of variation in a data set that may be used is the coefficient of variation (CV) which is the standard error expressed as a percentage of the mean.

Some experiments will report a correlation coefficient (r) which is a measure of the degree of association between two variables. Values can range from –1 to +1. A strong positive correlation (close to +1) between two variables indicates that if one variable has a high value then the other variable is likely to have a high value also. Similarly, low values of one variable tend to be associated with low values of the other variable. In contrast, a strong negative correlation coefficient (close to –1) indicates that high values of one variable tend to be associated with low values of the other variable. A correlation coefficient close to zero indicates that there is not much association between values of the two variables (i.e. the variables are independent). Correlation is merely a measure of association between two variables and does not imply cause and effect.

Other experiments use similar procedures known as regression analysis to determine treatment differences. The regression coefficient (usually denoted as b) indicates the amount of change in a variable Y for each one unit increase in a variable X. In its simplest form (i.e. linear regression), the regression coefficient is simply the slope of a straight line. A regression equation can be used to predict the value of the dependent variable Y (e.g. performance) given a value of the independent variable X (e.g. treatment). A more complicated procedure, known as multiple regression, can be used to derive an equation that uses several independent variables to predict a single dependent variable. Associated statistics are r^2, the simple coefficient of determination, and R^2, the multiple coefficient of determination. These statistics indicate the proportion of the variation in the dependent variable that can be accounted for by the independent variables.

Genetic studies may report estimates of heritability (h^2) or genetic correlation (r_g). Heritability estimates refer to that portion of the phenotypic variance in a population that is due to heredity. A genetic correlation is a measure of whether or not the same genes are affecting two traits and may vary from –1 to +1.

COMMON ABBREVIATIONS

ADFI = average daily feed intake
ADG = average daily gain
avg = average
BW = body weight
cc = cubic centimeter
cm = centimeter
CP = crude protein
CV = coefficient of variation
cwt = 100 pounds
d = day(s)
DM = dry matter
DNA = deoxyribonucleic acid
°C = degrees Celsius
°F = degrees fahrenheit
EPD = expected progeny difference
F/G = feed:gain ratio
FSH = follicle stimulating hormone
ft = foot/feet
g = gram(s)
gal = gallon(s)
h = hour(s)
in = inch(es)
IU = international units
kcal = kilocalorie(s)
kg = kilogram(s)
L = liters(s)
lb = pound(s)
LH = lutenizing hormone
m = meters
mg = milligram(s)
mcg = microgram(s)
mEq = millequivalent(s)
min = minutes(s)
mo = month(s)
N = nitrogen
NS = not significant
ppb = parts per billion
ppm = parts per million
r = correlation coefficient
r^2 = simple coefficient of determination
R^2 = multiple coefficient of determination
RNA = ribonucleic acid
s = second(s)
SD = standard deviation
SE = standard error
SEM = standard error of the mean
TDN - total digestible nutrients
wk = week(s)
wt = weight
yr = year(s)

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Developing Future Leaders of the Animal Industries

Charles Rosenkrans, Jr., and Wayne Kellogg[1]

Story in Brief

Numerous former students who had majored in Animal or Poultry Science at the University of Arkansas have made very significant impacts in allied industries and academia. Our objective is to continue graduating students who make a difference. Curricula is a very dynamic process, and we are continuing to make changes to our undergraduate and graduate degree programs. To ensure excellence, we are offering new courses, and improving academic policies and procedures.

Undergraduate Studies

Diversity is a great opportunity for broadening student education. During the 1999-2000 academic year we will unveil our new undergraduate courses related to companion animals. Three new courses will be offered: Animal Behavior, Companion Animal Management, and Parasitisms of Domesticated Non-Herbivores.

Animal Behavior is a sophomore-level course taught by Dr. Hayden Brown. This course is aimed at understanding why animals do what they do. Specifically, students will study how environmental, genetic, nutritional, and physiological factors control the way livestock and pets behave. Companion Animal Management is a sophomore-level course taught by Dr. Dianne Hellwig. While this course will primarily consider the genetics, nutrition, physiology and management of dogs and cats, some attention also will be given to pet birds and reptiles. Our third new course, Parasitisms of Domesticated Non-Herbivores, is a junior level course taught by Dr. Tom Yazwinski. As the name implies, this course will primarily cover parasites of pets, birds, and swine. Collectively, we believe these courses will enhance the educational opportunities for students who come from urban areas or who just want to know more about companion animals. Our hope is that these courses will not only serve our current clientele, but prove attractive to students in other disciplines and colleges within the university.

In addition to the courses related to companion animals, we are building and investing in our equine program. Later this year, our plans are to open the Dorothy E. King Equine Pavilion and to hire an instructor for equine and equestrian courses. Programs for students and the public are planned at the new facilities, which should result in quick recognition of the usefulness of such facilities.

Undergraduate Programs

The University of Arkansas experienced a fairly flat increase (1.4%) in student enrollment in comparison to spring 1998. However, the Bumpers College had an increase of nearly 15%, by far the largest in the university. That increase in enrollment can be attributed to a large number of factors including recruitment programs and development of the Arkansas Consortium for Teaching Agriculture (ACTA). Animal Science had one of the largest increases in enrollment amongst the agriculture departments. We had 117 students, which is a 26% increase when compared with 1998.

While Animal Science enrollment is growing, we are not going to rest. Our recruitment program includes a more organized faculty effort and considerably more lucrative scholarship program. We continue to support Animal Science courses with our ACTA partners through distance education and cooperative syllabi. This relatively new partnership has already resulted in considerable interest in Animal Science transfers to the University of Arkansas.

Retention can be a serious problem in open enrollment public institutions, and is a problem at the University of Arkansas. The University of Arkansas has implemented a incremental increase in admission requirements; however, additional programs are needed to increase retention. We believe that offering a student-centered academic program with interesting and challenging curricula is key. Our retention program will include both peer-to-peer mentoring and faculty-student mentoring, as well as faculty advising. Implementation of the electronic degree audit system will allow faculty more time for advising students as opposed to just class scheduling. In total, we hope to continue attracting good students who have the drive to succeed and become the leaders of agriculture.

[1] Both authors are associated with the Animal Science Department, Fayetteville.

Graduate Programs

Our graduate enrollment is growing again. Currently we have 31 students with 20 on assistantship with the largest percentage of those students being Master of Science candidates. During the past three years most of the attention in curricula has focused on undergraduate studies. That momentum is now shifting to the graduate program.

The physiology groups of Animal Science and Poultry Science reorganized two 4-hour general physiology courses into six 2-hour modular courses. Those 8-week block courses are: Neurophysiology, Cardiovascular Physiology, Endocrine Physiology, Respiratory Physiology, Gastrointestinal and Digestive Physiology, and Renal Physiology. This change will allow for greater student/mentor variety in course selection and instructor specialization for each course. In addition, the modular format will be more conducive for delivery via distance education.

An interdepartmental group of monogastric nutritionists is developing a series of integrated course offerings. Those courses include adding a laboratory methods course, and a protein metabolism course. In addition, our faculty interested in meats, muscle biology, and food safety are discussing curriculum opportunities with Poultry Science and Food Science faculty.

Collectively, our undergraduate and graduate teaching programs is preparing students for the diverse career opportunities that await them. The combination of coursework, internships, and extracurricular activities allow our students to become aquainted with unique opportunities in the animal industry.

Teaching Concepts of Forage Quality and Estimation of Energy in Forages on a Graduate Level[1]

W.K. Coblentz[2], C.P. West[3], and K. Anschutz[2]

Story in Brief

This report describes a laboratory exercise for graduate students that was designed to provide practical experience in conducting forage quality analysis. Students in Forage-Ruminant Relations (ANSC/AGRN 6253) were paired and assigned a bermudagrass hay sample selected from the Arkansas Hay Show. A set of laboratory procedures was completed for each sample and the results were reported orally and in a written report. The energy content of these forages was predicted by several equations used routinely across the United States. Most students felt the activity was useful and should be repeated in subsequent classes. This activity may have been most beneficial to students pursuing advanced degrees in programs other than ruminant nutrition; these students may have no other exposure to these procedures during their advanced academic training.

Introduction

Teaching concepts of forage quality is best accomplished with laboratory experience to support the theoretical concepts discussed in the classroom. Many students, who may never conduct forage quality analysis on a routine basis, still need to have some understanding of these concepts in their future careers. Students that pursue careers as consultants or in some other extension-related field can benefit greatly from having some knowledge of what information can and can not be gleaned from each laboratory procedure. In addition, an appreciation for the time, expense, and logistical requirements necessary to conduct these procedures may also be of great benefit when these students join the professional work force. In order to provide graduate-level students with this type of training, a laboratory study problem was designed for the students enrolled in Forage-Ruminant Relations (ANSC/AGRN 6253). One concept that often surprises students, producers, and county extension personnel is that there is no standard method of estimating the energy content of forages. Because the direct determination of the digestible energy content of feedstuffs using animals is prohibitively expensive and time consuming, energy estimates are usually predicted from equations that use values obtained from routine forage quality procedures. However, these prediction equations are not standardized across the country, region, or even within a given state. For instance, forage samples sent to the University of Arkansas Agricultural Services Laboratory will have the associated energy content predicted by equations that are different from those used by private laboratories. In addition, some states have one prediction equation for all forages, while other states have separate equations for different forage types (legumes, corn silage, cool-season grasses, warm-season grasses, etc.). Our objectives in designing this problem were twofold: 1) supplement classroom discussions about forage quality with valuable laboratory experience; and 2) demonstrate the differences in predictive equations for the energy content of forages that can occur across the country.

Procedures

Sample Selection and Analyses. During the 1998 Arkansas Hay Show held in conjunction with the Arkansas Cattlemen's Association Convention, four high-quality samples of bermudagrass hay were selected for this project. Most prediction equations for energy rely heavily on the acid detergent fiber (ADF) concentration as the predictor variable; however, the University of Arkansas prediction equation for energy or total digestible nutrients (TDN) also includes concentrations of neutral detergent fiber (NDF) and crude protein (CP). The four bermudagrass samples were selected because they had similar levels of ADF, but a wide range of CP concentrations (Table 1). Selection was based on the required laboratory analysis submitted with each entry in the hay show. An alfalfa sample that had been analyzed previously (Coblentz et al., 1998) was included as a control. All samples were dried to constant weight at 122°F and subsequently ground through a 1-mm screen with a Wiley mill (Arthur H. Thomas, Philadelphia, Pennsylvania).

[1] Students in ANSC/AGRN 6253 included Indi Braden, Stephanie Williamson, Dana Mattke, Mike Nihsen, Jeff Weyers, Dean Scarbrough, Levi McBeth, Keith Lesmeister, Eric Oxford, and Clay Bailey.

[2] Department of Animal Science, Fayetteville.

[3] Department of Crop, Soil and Environmental Sciences, Fayetteville.

Samples were analyzed in the University of Arkansas Ruminant Nutrition Lab for nitrogen (N), NDF, ADF, cellulose, lignin, *in vitro* dry matter disappearance (IVDMD), and *in vitro* organic matter disappearance (IVOMD). Total plant N was determined using a macro-Kjeldahl procedure (Kjeltec Auto 1030 Analyzer, Tecator, Inc., Herndon, Virginia); CP was calculated as percent N x 6.25. Neutral detergent fiber (omitting sulfite), ADF, lignin, cellulose, hemicellulose, IVDMD, and IVOMD were determined by or calculated on the basis of batch procedures outlined by ANKOM Technology Corp. (Fairport, New York). Prior to analysis, one sample was assigned to a pair of students. Each student conducted these analyses in duplicate on their sample.

Energy Equations. After completing the assigned laboratory procedures for each sample, students were asked to calculate TDN using the appropriate prediction equations of three states (Arkansas, Missouri, and Florida). Equations are shown below.

Florida:

(all forages) TDN = organic matter x
(26.8 + [0.595 x IVOMD]) / 100

Arkansas:

(legume) TDN = 73.5 + (0.62 x CP) - (0.71 x ADF)
(warm-season grass) TDN = 111.8 +
(0.95 x CP) - (0.36 x ADF) - (0.7 x NDF)

Missouri:

(legume) TDN = 97.192 - (1.0664 x ADF)
(grasses) TDN = 93.9656 - (0.9632 x ADF)

At the end of the semester, students were asked to make an oral presentation in class and submit a written report of their work. Results were tabulated and discussed in class. In the written report, students were required to evaluate this activity and make suggestions to improve it for subsequent classes. At least one question on the final exam, which was an oral exam, was based on the class reports and subsequent classroom discussion.

Results

Forage Analysis. Mean values for quality indices of each forage sample (from each pair of students) are shown in Table 2. Although the students were successful in achieving relatively good precision in most laboratory procedures (data not shown), class results did not agee well with those submitted at the Arkansas Hay Show. Forages B, C, and D had similar ADF concentrations (range = 33.0 to 34.2), but these values were substantially higher than those submitted with the samples (range = 26.1 to 28.4). Our ADF concentration for forage A (25.0%) was somewhat lower than the submitted value (28.0%). Generally, agreement between class and submitted CP concentrations was better than for ADF. These results illustrated the differences that can occur between laboratories.

Digestibility and Energy Calculations. Determinations of IVDMD, IVOMD, and calculations of TDN are shown in Table 3 and indicate clearly the high quality of these bermudagrass hays. Estimates of TDN by the Arkansas equation were consistently higher than other estimates; the inclusion of CP as a predictor variable in the Arkansas equation for warm-season grasses clearly had a large impact on predicted TDN values (Fig. 1). Prediction of TDN by other equations was clearly less sensitive to CP concentrations. Considerable class discussion time was devoted to possible explanations for this trend. Current management practices, particularly the heavy reliance on poultry litter or commercial N fertilizer, may drive CP concentrations in bermudagrass beyond the range in which the Arkansas TDN equations were developed. When this happens, substantial overestimation of TDN may occur.

Class Evaluation. All students were required to evaluate this activity in their final written report. Most comments were favorable; students generally recommended that this project be repeated in subsequent classes because it gave them some practical experience with forage analysis that could be useful in the future. Students liked being paired because they could share laboratory responsibilities when conflicts arose with other commitments. Most felt the work load was reasonable, given there was no scheduled laboratory period. Some students expressed frustration with some of the calculations. In-depth example calculations will be provided if the activity is repeated in the future.

Implications

This activity was conducted in an effort to promote better understanding of forage quality analysis. In addition, it was designed to help students understand the problems inherent in predicting the energy content of forages. Students generally felt the activity was helpful in meeting these goals. This activity may have been most beneficial to students pursuing advanced degrees in programs other than ruminant nutrition; these students may have no other exposure to these procedures during their advanced academic training.

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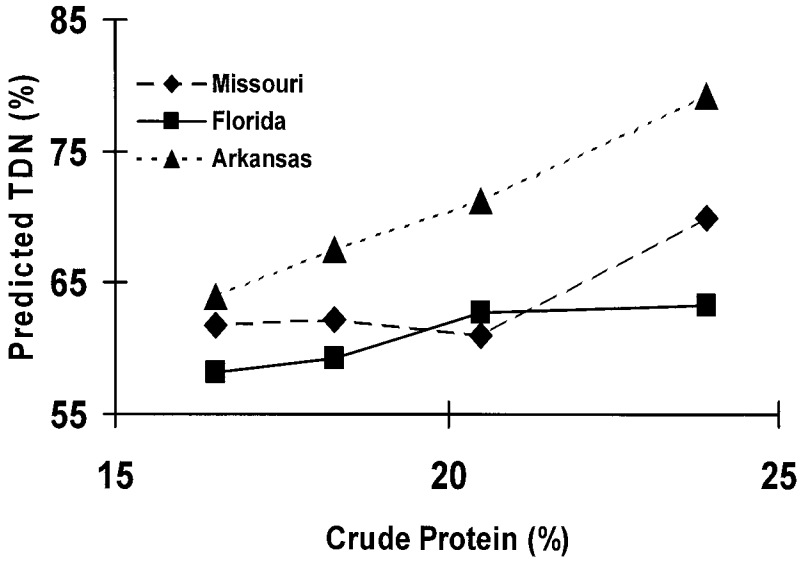

Fig. 1. Relationship between CP concentration and predicted TDN values for four bermudagrass samples selected from the Arkansas Hay Show and evaluated by the students enrolled in ANSC/AGRN 6253.

Table 1. Laboratory analyses submitted with hay samples at the 1998 Arkansas Hay Show. The alfalfa sample had been evaluated previously (Coblentz et al., 1998) and was placed in the project as a control.

Forage	Crude protein	ADF
	%	%
Bermudagrass A	22.4	28.0
Bermudagrass B	19.6	26.1
Bermudagrass C	17.3	27.9
Bermudagrass D	15.4	28.4
Alfalfa	21.1	34.7

Table 2. Analysis of five test forages by five student pairs.

Forage	DM[1]	OM	Ash	NDF	ADF	Hemicellulose	Cellulose	Lignin	Nitrogen	Crude protein
	%	----------% of DM ----------								
Bermudagrass A	95.3	91.7	8.26	66.1	25.0	41.1	24.5	2.71	3.80	23.9
Bermudagrass B	95.9	93.9	6.15	68.2	34.2	34.0	27.4	3.51	3.28	20.5
Bermudagrass C	93.0	92.0	7.98	71.0	33.0	38.0	27.3	3.85	2.92	18.3
Bermudagrass D	94.4	93.3	6.69	73.6	33.4	40.3	29.6	3.19	2.64	16.5
Alfalfa	93.0	90.1	9.97	42.6	31.8	10.8	25.1	5.97	3.41	21.4

[1] Abbreviations: DM = dry matter, OM = organic matter, NDF = neutral detergent fiber, and ADF = acid detergent fiber.

Table 3. Determinations of digestibility and energy calculations for five test forages.

Forage	IVDMD[1]	IVOMD	Arkansas TDN equation	Missouri TDN equation	Florida TDN equation
	%	%	%	%	%
Bermudagrass A	71.8	70.9	79.2	69.9	63.3
Bermudagrass B	67.9	67.3	71.3	61.0	62.8
Bermudagrass C	62.1	63.3	67.6	62.2	59.3
Bermudagrass D	61.4	59.7	64.0	61.8	58.2
Alfalfa	71.4	71.8	64.2	63.3	62.6

[1] Abbreviations: IVDMD = *in vitro* dry matter disappearance, IVOMD = *in vitro* organic matter disappearance, and TDN = total digestible nutrients.

Efficacy of Mannan Oligosaccharide (Bio-Mos®) Addition at Two Levels of Supplemental Copper on Performance and Immunocompetence of Early Weaned Pigs

Ellen Davis, Charles Maxwell, Beth Kegley, Brenda de Rodas, Kim Friesen, and Dianne Hellwig[1]

Story in Brief

An experiment involving 216 weanling barrows (1/2 Large White x Duroc x Landrace; 12.7 lb BW and 21 ± 2 days of age) was conducted to determine the efficacy of dietary Bio-Mos® addition at two levels of supplemental copper on performance and immune response. Pigs were blocked based on body weight and penned in groups of six (9 pens/treatment) in an offsite nursery. Dietary treatments were arranged as a 2 x 2 factorial consisting of two copper levels (10 and 185 ppm) with and without Bio-Mos (0 or .2%). Experimental diets were fed throughout the study (day 0 to 38, postweaning) and contained 1.50% lysine during Phase 1 (day 0 to 10), 1.35% lysine during Phase 2 (day 10 to 24), and 1.20% lysine during Phase 3 (day 24 to 38). Two pigs from each pen were bled to measure *in vitro* cellular immune response using a lymphocyte blastogenesis assay. During Phase 1, ADG and ADFI increased with the addition of Bio-Mos at 10 ppm copper, but decreased at 185 ppm copper (interaction, $P < .002$ and $P < .1$, respectively). Similarly, F/G was lower when Bio-Mos was added to diets containing 10 ppm copper, but increased when Bio-Mos was added at 185 ppm supplemental copper (interaction, $P < .02$). Pigs fed diets with 185 ppm copper during Phases 2 and 3 had greater ($P < .04$) ADG and ADFI than those fed 10 ppm copper, while Bio-Mos addition during Phase 3 resulted in improved ADG ($P < .04$) and F/G ($P < .09$) compared to diets devoid of Bio-Mos. This study indicates that the performance response to Bio-Mos in Phase 1 varied with level of dietary copper. However, in Phases 2 and 3, diets containing either Bio-Mos or 185 ppm copper resulted in improved performance.

Introduction

Swine production in the southern states has increased rapidly with most of the increase occurring in sow farms. Typically, pigs are commingled at weaning and reared in offsite nursery units before being transported to the corn belt for finishing. The stress of commingling pigs prior to the nursery phase of production and of long distance hauling to finishing presents a challenge for the swine industry. Growth promoters such as antibiotics and pharmacological levels of copper are commonly added to feed to overcome the potential performance and health problems associated with these stressful production practices. However, concern over bacterial resistance to antibiotics and environmental problems with additions of high levels of trace minerals has challenged the swine industry to develop alternative products. Polysaccharides derived from yeast cell walls have been shown to improve performance and enhance immune function. For instance, the addition of mannan oligosaccharide (Bio-Mos®) to milk replacer improved gain and intake in young calves (Dvorak and Jacques, 1997). The objective of this study was to assess the efficacy of Bio-Mos addition to the diets of weanling pigs, and compare their performance to pigs fed high copper diets.

Experimental Procedures

A total of 216 weanling barrows were transported to an offsite nursery and blocked according to initial body weight (BW). Pigs within each block were allotted into equal subgroups (six pigs/pen) and randomly assigned to treatments within each block. Four dietary treatments consisting of two levels of inorganic copper (10 or 185 ppm) with and without the addition of Bio-Mos (0 or 0.2%) were arranged as a 2 x 2 factorial and fed during Phase 1 (day 0 to 10), Phase 2 (day 10 to 24), and Phase 3 (day 24 to 38). Basal diets in each of the three phases (Table 1) were supplemented with 0.07% copper sulfate ($CuSO_4$) or 0.2% Bio-Mos at the expense of corn to provide four diets in each phase with and without Bio-Mos and with and without 175 ppm supplemental $CuSO_4$.

Pig BW and feed intake were determined at the initiation and termination of Phase 1, and weekly during Phases 2 and 3. Average daily gain, ADFI, and F/G were calculated. *In vitro* cellular response was measured using a lymphocyte

[1] All authors are associated with the Department of Animal Science, Fayetteville.

blastogenesis assay (Blecha et al., 1983). One 15 ml heparinized blood sample was taken via venipuncture for isolation of mononuclear cells from two randomly selected pigs in each pen (total of 18 pigs/treatment, 72 pigs total). Samples were obtained on day 28, 30, 32, and 34 of the study with 25% of the pens sampled on each of the four days. Phytohemagglutinin (PHA) and pokeweed mitogen (PWM) were used as mitogens at a concentration of 50 and 25 mg/ml, respectively. Incubation, radioactive labeling, and cell harvesting followed procedures outlined by van Heugten and Spears (1997).

Performance data and lymphocyte proliferation were analyzed as a randomized complete block design with pen as the experimental unit. Analysis of variance was performed using the GLM procedure of SAS (1988), and the effects of $CuSO_4$, Bio-Mos, and $CuSO_4$ x Bio-Mos interaction were evaluated.

Results and Discussion

Treatment means are presented where a $CuSO_4$ x Bio-Mos interaction was observed (Table 2), while data in which no interaction was observed and the results of the lymphocyte proliferation assay are presented as main effect means (Table 3). During Phase 1, ADG, ADFI, and F/G improved with the addition of Bio-Mos at 10 ppm copper, but ADG and ADFI decreased and F/G increased with Bio-Mos addition at 185 ppm copper (interaction, $P < .02$, $P < .1$, $P < .02$, respectively). Pigs fed diets supplemented with 185 ppm copper during Phase 2 and Phase 3 had greater ADG ($P < .003$ and $P < .02$ for Phases 2 and 3, respectively) and ADFI ($P < .02$ and $P < .04$ for Phases 2 and 3, respectively) than those fed diets with 10 ppm copper. Feed conversion was lower ($P < .02$) during Phase 2 when pigs were fed the higher level of copper. Additionally, ADG ($P < .04$) and F/G ($P < .09$) were improved in pigs fed diets supplemented with Bio-Mos in Phase 3 compared to pigs fed diets without Bio-Mos. For the overall trial (day 0 to 38), pigs fed diets containing 185 ppm copper had greater ($P < .003$) ADG and ADFI, and lower ($P < .003$) F/G than those fed diets containing 10 ppm copper. Pigs fed Bio-Mos had improved ADG ($P < .04$) and F/G ($P < .01$) than those fed diets with no Bio-Mos.

The performance results of this study are consistent with previous results in young pigs and poultry. As in the present study, Schoenherr et al. (1994) and Van der Beke (1997) reported improved weight gain and feed efficiency in weanling pigs when oligosaccharides were added to the diet, and addition of Bio-Mos improved rate of gain (Stanley et al., 1996) and efficiency (Kumprecht and Zoba, 1997) in broiler chicks.

Previous research has reported that a yeast glucan enhances non-specific immunity in fish (Raa et al., 1992; Engstad et al., 1992). In the present study, the effect of Bio-Mos on the immunocompetence of weanling pigs was evaluated by mitogen-stimulated lymphocyte proliferation. Although proliferation was numerically greater in stimulated cell cultures from pigs fed Bio-Mos, neither Bio-Mos nor dietary copper had a significant effect on lymphocyte proliferation. This lack of significant response may be attributed to the high level of variability observed in the animals that were sampled.

Implications

Pig performance in response to Bio-Mos addition during Phase 1 varied with level of dietary copper. However, in Phases 2 and 3, diets containing either Bio-Mos or 185 ppm copper resulted in improved performance. This study suggests that Bio-Mos may be an acceptable alternative to the inclusion of high levels of dietary copper in nursery pig diets.

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Table 1. Composition of basal diets[a].

Item, %	Phase 1	Phase 2	Phase 3
Yellow corn	39.32	48.11	62.375
Steam rolled oats	5.00	-	-
Deproteinized whey	17.50	10.00	-
Processed soy protein (Optipro)	6.75	-	-
Soybean meal, 48% CP	10.00	28.30	30.00
AP-301	2.00	2.00	-
AP-920	3.75	-	-
Select menhaden fish meal	8.50	4.00	-
Soybean oil	4.00	4.00	-
Fat	-	-	4.00
Ethoxyquin	.03	.03	.03
Lysine HCl	-	-	.16
Threonine	.05	-	-
Methionine	.15	.08	.02
Tylan-40	-	-	.125
Neoterromycin 10/5	1.00	1.00	-
Mineral premix (NB-8557B)[b]	.10	.15	.15
Vitamin premix (NB-6157B)[b]	.15	.25	.25
Dicalcium phosphate	1.30	1.40	1.88
Calcium carbonate	.10	.38	.61
Salt	.30	.30	.40
Calculated composition			
Lysine	1.50	1.35	1.20
Threonine	.98	.87	.77
Tryptophan	.27	.26	.24
Met + Cys	.90	.82	.72
Calcium	.90	.80	.80
Phosphorus	.80	.70	.70
Metabolizable energy, kcal/lb	1537	1542	1563
Lactose	14.53	8.3	-

[a] Basal diets were supplemented with 0.07% $CuSO_4$ or 0.2% Bio-Mos to provide four diets in each phase with and without Bio-Mos and with and without 175 ppm copper from $CuSO_4$. Copper and Bio-Mos were added at the expense of corn.

[b] Vitamins and minerals met or exceeded NRC requirements, 1998.

Table 2. Treatment means showing interaction effects of Bio-Mos and $CuSO_4$ on gain, feed intake, and feed conversion of segregated early weaned pigs.

	Control	$CuSO_4$	Bio-Mos	$CuSO_4$/Bio-Mos	
	Treatment				
	1	2	3	4	SE
Phase 1 (d 0 to 10)					
ADG, lb [a]	.23	.48	.35	.41	.03
ADFI, lb [b]	.54	.69	.60	.62	.04
F/G [a]	2.50	1.47	1.79	1.50	.13

[a] $CuSO_4$ x Bio-Mos“ interaction; $P < .02$.

[b] $CuSO_4$ x Bio-Mos“ interaction; $P < .10$.

Table 3. Main effects of Bio-Mos and copper sulfate addition to nursery pig diets.

	Bio-Mos		Copper sulfate		
	-	+	-	+	SE
Phase 2 (day 10 to 24)					
ADG, lb [a]	.88	.92	.83	.98	.03
ADFI, lb [b]	1.10	1.12	1.03	1.18	.04
F/G [b]	1.32	1.28	1.37	1.24	.04
Phase 3 (day 24 to 38)					
ADG, lb [b,c]	1.15	1.24	1.14	1.26	.03
ADFI, lb [d]	1.96	1.98	1.88	2.06	.06
F/G [e]	1.74	1.62	1.68	1.67	.05
Overall trial (day 0 to 38)					
ADG, lb [a,c]	.89	.94	.85	.98	.02
ADFI, lb [a]	1.35	1.36	1.28	1.43	.03
F/G [a,f]	1.62	1.49	1.65	1.46	.03
Lymphocyte proliferation, cpm [g]					
Unstimulated	455.29	431.00	447.56	438.73	55.35
PHA, 50 mg/ml	45010.90	43129.36	44974.42	43165.85	5038.07
PWM, 25 mg/ml	45180.86	49125.97	48589.46	45717.37	3913.91

[a] Copper sulfate effect; $P < .003$.
[b] Copper sulfate effect; $P < .02$.
[c] Bio-Mos effect; $P < .04$.
[d] Copper sulfate effect; $P < .04$.
[e] Bio-Mos effect; $P < .09$.
[f] Bio-Mos effect; $P < .01$.
[g] Data are means of nine pens/treatment with two pigs/pen. One blood sample was collected from each pig on one of four days beginning on day 28 and ending on day 34 of the trial. Data are expressed as counts per minute (cpm).

Effect of Feeding *Bacillus* Cultures on Performance of Growing-Finishing Swine and on Pen Cleaning Characteristics.

C.V. Maxwell, M.E. Davis, and D. Brown[1]

Story In Brief

A total of 112 crossbred gilts and barrows (Hampshire x Duroc sires mated to crossbred sows) were used in this study to determine the effect of feeding *Bacillus* cultures (MicroSource™ "S") on gain, feed efficiency, time required to clean pens, and on the dispersion characteristics of manure build-up in the pen. Average daily gain was similar among pigs fed the control diet or those fed MicroSource "S" in the starter, grower, and finisher diets and for the overall study. Pigs fed MicroSource "S" tended to consume less feed and tended to be more efficient in the starter, grower, and finisher phase of the study and for the overall study when compared to those fed the control diet. The time required to dissolve the manure mat was reduced by 33% in samples from pens where MicroSource "S" was fed when compared to samples from pens fed the control diet devoid of MicroSource "S". The improved dispersion characteristics resulted in a 17.5% reduction in the time required to clean pens. This study suggests that feeding MicroSource "S" results in similar gain to control animals with a small reduction in feed intake, which is accomplished by a small improvement in feed efficiency. In addition, this study suggests that the manure decomposition process by which MicroSource "S" prevents solids build-up in pits is enhanced prior to the placement of manure in the pit.

Introduction

Two major problems with the management of swine manure from pit storage systems are the production and accumulation of noxious odors and ammonia in confinement buildings and a build-up of manure solids. In recent years, the control of odors from swine production facilities has become a major issue for producers. With this has come a plethora of new manure treatment products. Unfortunately, many products on the market today which claim to reduce odor problems have no proven efficacy and are costly. Although some products have been shown to reduce odors, none of these products has effectively or economically addressed the cause of the problem, i.e. the decomposition process. Therefore, symptoms are treated but the root problem is not addressed.

Recently, researchers at Agtech Products, Inc. have developed a feed additive consisting of viable *Bacillus* bacteria which were selected for their ability to alter the decomposition process and effectively prevent the build-up of solids, volatile fatty acids, and ammonia in swine manure (Hammond et al., 1998; Turner et al., 1998). This feed additive is now commercially available from Loveland Industries, Inc., of Greeley Colorado and is marketed as MicroSource™ "S". The partial decomposition of the manure solids build-up in pens appears to reduce the difficulty and time required to clean pens between groups of pigs. Although MicroSource "S" may have an effect on altering the nutrient degradation process in the intestinal tract, studies have not been conducted to determine the effect of MicroSource "S" on feed efficiency or pig performance. Therefore, this study was conducted to determine the effect of feeding MicroSource "S" on performance and pen cleaning characteristics.

Experimental Procedures:

Allotment of pigs: A total of 112 crossbred gilts and barrows (Hampshire x Duroc sires mated to crossbred sows) were used in this study, which was conducted at the University of Arkansas swine farm. Pigs were moved from nursery facilities and fed the same medicated starter diet for one week prior to the initiation of the trial. Pigs were blocked by weight and allotted within block to equal subgroups (seven pigs/pens) based on litter and sex. Treatments were then assigned to pens within each of the weight groups. A total of eight pens were randomly allotted to each of two treatments, which continued throughout the starter, growing, and finishing periods. Pens assigned to treatment were scattered throughout the growing-finishing building to avoid direct contact of pigs from *Bacillus* treated pens with those receiving the control diet.

[1] All authors are associated with the Department of Animal Science, Fayetteville.

Experimental Treatments:

Two dietary treatments consisted of two levels of MicroSource "S" (0, or .05% MicroSource "S") in the starter, grower, and finisher diets (Table 1). The specific diets consisted of the following:

1) Treatment 1 - Control diet devoid of MicroSource "S".
2) Treatment 2 - Control diet + 0.05% MicroSource "S" (1 lb of MicroSource "S" per ton of feed).

A three-phase finishing program was used in the study with diet transition from starter to grower and from grower to finisher occurring when the mean weight of each block reached approximately 75 and 150 pounds, respectively. The control diet met or exceeded NRC (1988) requirements. Diets were formulated to contain 1.1% lysine during the starter period, 0.96% lysine during the grower period and 0.85% lysine during the finisher period.

Performance data: Pigs were removed from the study weekly as individuals reached approximately 230 pounds. Data collected were average daily gain, average daily feed intake, and feed required per unit of gain during the starter, grower, and finisher periods.

Pen cleaning time: The actual time required to clean pens with a combination of scraping and high pressure cleaning (2200 PSI high pressure cleaner) was determined upon completion of the feeding trial.

Dispersibility of manure build-up in the pen: Pens used in this study were 5' x 13' with 9' of solid concrete and 4' of concrete slats over a pit. Manure build-up typical of partially slatted pens was evident during the study. Two approximately 100-gram samples of the manure solids build-up (manure mat) in the solid concrete section in each pen were obtained from two locations in the pen. A small rectangular shaped manure mat sample weighing approximately 4.0g (3.85 to 4.09g) was cut from each manure mat. The samples were placed in a beaker with 500 ml of water at 25°C with a stirrer. The time required to completely disperse the solid mass with stirring action as evidenced by visual inspection was determined (minutes/g of sample).

Statistical Analysis: Performance data were analyzed as a randomized complete block design with pen as the experimental unit and blocks based on initial body weight. Analysis of variance was performed using the GLM procedures of SAS (1988).

Results and Discussion

Average daily gain was similar among pigs fed the control diet or those fed MicroSource "S" for each phase of the study as well as overall (Table 2). Pigs fed MicroSource "S" consumed less feed in the starter, grower, and finisher phase of the study and overall when compared to those fed the control diet with differences approaching significance in the grower phase (P=.12) and for the overall study (P=.13). The magnitude of reduction in feed intake was 2.7% for the overall study. Similarly, feed efficiency was improved in pigs fed MicroSource "S" in each phase of the study with differences approaching significance in the starter (P<.1) and for the overall trial (P=.14). The magnitude of improvement in feed efficiency was 4.3% for the overall study. This study suggests that pigs fed MicroSource "S" have similar gain when compared to non-supplemented pigs, which is the result of a small reduction in feed intake accompanied by a small improvement in feed efficiency.

The time required to pressure wash pens of the MicroSource "S" treated group was reduced by 17.5% from control group time, although differences were not significant. Correspondingly, the time required to dissolve the manure mat was reduced by 33% ($P < .03$) in samples from pens where MicroSource "S" was fed as compared to samples from pens fed the control diet devoid of MicroSource "S". The observation that the decomposition process of the manure mat was enhanced in pens when pigs are fed MicroSource "S" is consistent with the observation that viable *Bacillus* strains selected for their ability to alter the decomposition process can effectively prevent solids build-up in pits (Hammond et al., 1998). This study suggests that the decomposition process is enhanced prior to the placement of manure in the pit. Alteration of the decomposition process has also been associated with a reduction in volatile fatty acids in swine manure (Hammond et al., 1998) and reduced ammonia volatilization (Turner et al., 1998).

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Table 1. Composition of research diets.

Ingredient, %	Starter		Grower		Finisher	
	Control	Treatment	Control	Treatment	Control	Treatment
Corn	62.660	62.610	64.540	64.490	68.860	68.810
Soybean Meal, 48%	31.160	31.160	26.110	26.110	22.250	22.250
Fat, An & Veg	2.600	2.600	5.650	5.650	5.500	5.500
Phosphate, Dical	1.650	1.650	1.800	1.800	1.400	1.400
Limestone	0.970	0.970	0.920	0.920	1.210	1.210
Salt	0.500	0.500	0.500	0.500	0.500	0.500
Vit TM Premix	0.250	0.250	0.250	0.250	0.150	0.150
Tylosin - 40	0.125	0.125	0.125	0.125	0.050	0.050
Copper sulfate	0.050	0.050	0.070	0.070	0.050	0.050
Ethoxyquin	0.030	0.030	0.030	0.030	0.030	0.030
Microsource™ "S"	0.000	0.050	0.000	0.050	0.000	0.050
Composition calculated, Total						
Protein, crude	19.880	19.880	17.620	17.620	16.090	16.090
Lysine	1.100	1.100	0.960	0.960	0.850	0.850
Methionine	0.330	0.330	0.300	0.300	0.280	0.280
Met & Cys	0.650	0.650	0.590	0.590	0.550	0.550
Threonine	0.780	0.780	0.690	0.690	0.630	0.630
Tryptophan	0.270	0.270	0.230	0.230	0.210	0.210
Calcium	0.800	0.800	0.800	0.800	0.700	0.700
Phosphorus	0.690	0.690	0.690	0.690	0.600	0.600
Composition calculated, Available						
Protein, Dig.	16.050	16.050	14.280	14.280	13.100	13.100
Lys - Swine Dig.	0.910	0.910	0.780	0.780	0.690	0.690
Met - Swine Dig.	0.270	0.270	0.250	0.250	0.230	0.230
M & C - Sw. Dig.	0.470	0.470	0.420	0.420	0.400	0.400
Thr - Swine Dig.	0.590	0.590	0.520	0.520	0.470	0.470
Trp - Swine Dig.	0.170	0.170	0.150	0.150	0.130	0.130
Phosphorous	0.450	0.450	0.470	0.470	0.390	0.390

Table 2. Effect of Microsource™-"S" on performance of growing-finishing pigs and pen cleaning characteristics.[a]

	Control	Microsource™-"S"	Std Err
Phase 1[b]			
ADG, kg	0.50	0.50	0.019
ADFI, kg	1.28	1.25	0.044
Feed:gain	2.56	2.51	0.113
Phase 2[c]			
ADG, kg	0.86	0.87	0.024
ADFI, kg[d]	2.34	2.25	0.036
Feed:gain[e]	2.73	2.60	0.047
Phase 3[f]			
ADG, kg	1.00	1.02	0.031
ADFI, kg	3.02	2.97	0.067
Feed:gain	3.02	2.92	0.070
Combined[g]			
ADG, kg	0.79	0.80	0.012
ADFI, kg[h]	2.21	2.15	0.027
Feed:Gain[i]	2.79	2.67	0.059
Clean Time, min			
Scrape time	19.11	19.84	6.55
Wash time	13.60	11.22	2.07
Total time	32.71	31.06	8.46
Dissolve Time, min[j]	54.38	36.40	5.64

[a]Data is comprised of 96 pigs (16 pens with six pigs/pen and eight pens/treatment).
[b]Phase 1 consisted of pigs from 50-75 lb.
[c]Phase 2 consisted of pigs from 75-150 lb.
[d]Treatment effect, P=.12.
[e]Treatment effect, P<.10.
[f] Phase 3 consisted of pigs from 150-230 lb.
[g]Combined data is comprised of pigs from 50 to 230 lb.
[h]Treatment effect, P=.13.
[i] Treatment effect, P=.14.
[j] Time Required to dissolve manure mat in water. Treatment effect, P <.03.

Influence of Magnesium-Mica on Performance and Carcass Quality Traits of Growing-Finishing Swine[1]

Jason Apple, Charles Maxwell, Brenda de Rodas, Jesse Davis, and Lillie Rakes[2]

Story in Brief

A total of 120 crossbred gilts and barrows were used to determine the effect of feeding Magnesium-Mica during the growing-finishing period on gain, efficiency of gain, and on carcass traits. Inclusion of Magnesium-Mica in the diet at 1.25 or 2.50% had no deleterious ($P > .10$) effect on average daily gain, average daily intake, or feed efficiency. Carcasses from pigs fed 1.25% Magnesium-Mica were trimmer ($P < .05$) and had higher ($P < .10$) lean muscle yields than carcasses from pigs fed the control diet. Additionally, pork loins from pigs fed 1.25% Magnesium-Mica had higher ($P < .05$) ultimate muscle pH values, and lower ($P < .10$) CIE a* and b* values compared to pork loins from swine fed the control diets or 2.50% Magnesium-Mica. Results from this study suggest that Magnesium-Mica addition to swine diets may reduce cost of gain without affecting performance, and may provide ingredients that improve lean muscle yields and affect pork quality.

Introduction

Magnesium-Mica is used primarily in the feed industry as a pellet binder and as a carrier for micro-mineral premixes. Some studies, however, indicate that Magnesium-Mica may have additional nutritional benefits beyond the excellent physical characteristics. In a recent study in our laboratory (Maxwell et al., 1998), inclusion of Magnesium-Mica in the diet of growing-finishing swine at levels of 1.25 or 2.50% had no deleterious effect on average daily gain (ADG), average daily feed intake (ADFI), or feed-to-gain ratio (F:G), and decreased the cost of gain. Color score measured at the 10th rib was improved in carcasses from pigs fed Magnesium-Mica when compared to carcasses from pigs fed a control diet devoid of supplemental magnesium. This is consistent with the observations of D'Souza et al. (1998), who reported improvements in subjective color scores of pork from pigs fed a diet supplemented with magnesium-aspartate. Additionally, D'Souza and co-workers (1998) found that inclusion of magnesium-aspartate in the diet of finishing pigs reduced longissimus muscle drip loss percentage. Therefore, the primary objective of this study was to confirm the effects of Magnesium-Mica in the diet of growing-finishing pigs on performance traits and to further evaluate the efficacy of Magnesium-Mica in improving carcass quality.

Experimental Procedures

One hundred and twenty crossbred gilts and barrows were moved from the nursery unit to the University of Arkansas Swine Farm, and blocked by weight, litter, and sex and randomly allotted to 24 pens (five pigs/pen) at an average weight of 45 to 50 lb. Pigs were fed a three-phase diet with transition from starter to grower and from grower to finisher occurring when the mean weight of each block reached approximately 75 and 150 lb, respectively. A total of eight pens were randomly allotted to each of three treatments: 1) control diet (0%) that met or exceeded NRC (1988) requirements; 2) control diet supplemented with 25 lb of Magnesium-Mica per ton of feed (1.25%) added at the expense of corn; and 3) control diet supplemented with 50 lb of Magnesium-Mica per ton of feed (2.50%) added at the expense of corn. All pigs received a standard corn-soybean meal diet formulated to contain 1.1% lysine during the starter phase, 0.95% lysine during the growing period, and 0.85% lysine during the finishing phase (Table 1). During each feeding phase, farm personal recorded ADG, ADFI, and F:G information.

When the lightest block averaged 235 lb, all pigs were transported approximately 450 miles to the Seaboard Farms, Inc., pork packing plant in Guymon, Oklahoma. After a 24-

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[2] All authors are associated with the Department of Animal Science, Fayetteville.

hour chilling and tempering period, carcasses were fabricated, and subjective evaluations of muscle firmness, marbling, and color (NPPC and Japanese color scores) were made by plant personnel on the loin eye muscle of boneless pork loins after a 30-minute "bloom" period. Commission Internationale de L'Eclairage (CIE) L*a*b* (CIE, 1976) reflectance values were measured with a Minolta CR-310B Chroma Meter (Minolta Camera, Higashi-Hu, Osaka, Japan) and 24-hour muscle pH was measured using an automated pH probe on each loin. Boneless pork loins were subsequently vacuum-packaged and shipped to the University of Arkansas Red-Meat Abattoir for further carcass quality measurements.

At approximately 48 hours postmortem, a 2-inch portion of the loin (cranial end) was removed, and a 2-g sample was excised for muscle pH measurement following the protocol outlined by Bendall (1973). Boneless loin chops were removed perpendicular to the muscle fiber orientation in the following order: 1) 1-inch thick chop; 2) 1.5-inch thick chop; 3) 1-inch thick chop; and 4) 1.5-inch thick chop.

The two 1.5-inch thick chops were used for drip loss determinations following the suspension procedure of Honikel et al. (1986). A 1.5-inch diameter core was removed from each 1.5-inch thick chop, weighed, and suspended on a fishhook (barb removed) mounted to the lid of a plastic container (18 inches deep x 15 inches wide x 24 inches long), and stored at 34°F. After 48 hours, each core was blotted with a paper towel and reweighed. The loss in weight due to drip and evaporation was divided by the original weight, multiplied by 100, and reported as drip loss percentage. Two additional 1-in thick chops were removed from the loin, and, after a 45-minute bloom period, NPPC and Japanese color scores were recorded, along with marbling scores. Also, CIE L*a*b* values were collected with a Hunter MiniScan XE (Hunter Associates Laboratory, Inc., Reston, Virginia).

Performance data were analyzed as a randomized complete block design with pen as the experimental unit and blocks based on initial weight. Analysis of variance was performed using the GLM procedure of SAS (1988). Linear and quadratic polynomials were used to detect the response to inclusion level of Magnesium-Mica in the diet (0, 1.25, and 2.50%). Pork quality data was also analyzed with the GLM procedure, and Magnesium-Mica level, sex and block were the main effects in the model. Means were separated statistically using the least significant difference procedure (SAS, 1988).

Results and Discussion

Inclusion of Magnesium-Mica in the diet at either 1.25 or 2.50% had no effect ($P > .10$) on ADG, ADFI, or feed efficiency (F:G) during the starter, grower, or finisher periods (Table 2). This is consistent with our laboratory's earlier findings (Maxwell et al., 1998). Moreover, Coffey and Brazle (1995) and Coffey et al. (1995) reported that performance of cattle was not affected by inclusion of Magnesium-Mica in feedlot diets.

The effects of Magnesium-Mica on carcass characteristics are presented in Table 3. Pigs fed the control diet were fatter ($P < .05$) at the 10th rib than pigs fed 1.25% Magnesium-Mica. Even though loin eye depth was not affected ($P > .10$) by inclusion of Magnesium-Mica, pigs fed 1.25% Magnesium-Mica had higher ($P < .10$) lean muscle yields than pigs fed the control diets. In our earlier trial (Maxwell et al., 1998), we failed to observe any differences in backfat measurements, loin eye area, or percent muscle. Our information also contradicts the findings of D'Souza et al. (1998) and Schaefer et al. (1993), who reported that inclusion of magnesium-aspartate in the finishing diets of pigs had no effect on carcass fat and muscling measurements.

Inclusion of Magnesium-Mica in growing-finishing diets had no effect ($P > .10$) on marbling scores, firmness scores, or NPPC color and Japanese color scores (Table 3). Moreover, magnesium-supplementation had no effect ($P > .10$) on loin eye muscle pH or Minolta CIE L*, a*, and b* values. Pork quality data collected at the University of Arkansas 48 hours after slaughter are presented in Table 4. Pork loins from pigs fed 1.25% Magnesium-Mica had higher ($P < .05$) muscle pH values than pigs fed the control diet or 2.50% Magnesium-Mica. Inclusion of Magnesium-Mica in the diets of growing-finishing swine had no ($P > .10$) appreciable effects on marbling or color scores. Additionally, Magnesium-Mica had no effect ($P > .10$) on objective measurements of lightness/darkness (L* values) taken at the University of Arkansas some 48 hours after slaughter. However, loin eye muscles from pigs fed 1.25% Magnesium-Mica were less ($P < .10$) red and less ($P < .05$) yellow (indicated by lower a* and b* values, respectively) than the loin eye muscle from pigs fed the control diet or 2.50% Magnesium-Mica. Additionally, the loin eye muscle from pigs fed 1.25% Magnesium-Mica had a lower ($P < .05$) mean saturation index compared to the other dietary treatments, indicative of a less vivid, or pure, color.

Typically, the higher the muscle pH the darker the color, and muscle pH values below 5.3 are used to define the PSE condition in pork muscle. Even though the loin eye muscle from pigs supplemented with 1.25% had the highest muscle pH values, the muscle color was determined to be less red (lower a* values) and less "vivid" (lower saturation index values) than loin eye muscles from pigs fed control diets or 2.50% Magnesium-Mica.

The failure of dietary inclusion of Magnesium-Mica to improve loin eye muscle color was somewhat disturbing considering that previous research from our laboratory showed that the mean NPPC color score increased with increasing Magnesium-Mica in the diet (Maxwell et al., 1998). However, this may be attributed to two primary differences between these trials. First, the genetics of pigs at the University of Arkansas Swine Farm have changed considerably since the initial study, with a concerted effort to remove all halothane-positive and carrier genetics. Second, carcasses were chilled differently following slaughter. Pigs in the previous study (Maxwell et al., 1998) were slaughtered at the University of Arkansas and carcasses were chilled conventionally

for 24 hours in a 34°F cooler, whereas carcasses in the present study were exposed to a rapid-chill system (carcasses are exposed to –40°F temperatures during the first 4 to 6 hours of chilling, then stored at 34°F until fabrication at approximately 24 hours postmortem). This system has been shown to effectively reduce the incidence of pale, soft, and exudative (PSE) carcasses. In the first study (Maxwell et al., 1998), the improvement in NPPC color scores was attributed to a reduction in carcasses receiving a color score of 1, which is indicative of PSE meat; thus, the rapid-chill system, employed in the present study, could have reduced and/or eliminated any marginally PSE-type carcasses.

Finally, inclusion of Magnesium-Mica in diets of growing-finishing swine had no effect ($P > .10$) on drip loss percentages (Table 4). Our results conflict with those of Schaefer et al. (1993) and D'Souza et al. (1998), who reported that supplementing finishing diets with magnesium-aspartate, at a rate of 40 g/pig for five days prior to slaughter, reduced the percentage of drip loss. Again, the failure to elicit an effect on drip loss may be a reflection in the genetic-line of swine used and the different chilling procedures used during each experiment

Implications

Results from this study confirm that inclusion of Magnesium-Mica in the diet of growing-finishing swine at a level of 1.25 or 2.50% has no deleterious effects on live animal performance, and may decrease cost of gain. Even though no improvements in pork color, and other pork quality attributes, were noted, inclusion of Magnesium-Mica at a rate of 1.25% may have beneficial effects on fat depth and lean muscle yields.

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Table 1. Composition of experimental diets.

Ingredient, %	Starter			Grower			Finisher		
	Trt #1	Trt #2	Trt #3	Trt #1	Trt #2	Trt #3	Trt #1	Trt #2	Trt #3
Magnesium-Mica[a]	0.00	1.25	2.50	0.00	1.25	2.50	0.00	1.25	2.50
Corn	61.775	60.275	59.095	66.975	65.725	64.295	71.115	69.865	68.615
Soybean meal, 48%	30.75	31.00	30.90	25.60	25.60	25.75	21.90	21.90	21.90
Fat, animal & vegetable	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Dicalcium phosphate	1.55	1.55	1.60	1.65	1.65	1.70	1.45	1.45	1.50
Calcium carbonate	0.82	0.82	0.80	0.77	0.77	0.75	0.68	0.68	0.63
Salt	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Mineral premix	0.15	0.15	0.15	0.15	0.15	0.15	0.10	0.10	0.10
Vitamin TM premix	0.25	0.25	0.25	0.15	0.15	0.15	0.125	0.125	0.125
Tylosin-40	0.125	0.125	0.125	0.125	0.125	0.125	0.05	0.05	0.05
Copper sulfate	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Ethoxyquin	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
	----------Calculated total composition----------								
Crude protein, %	20.17	20.16	20.01	18.11	18.00	17.95	16.67	16.56	16.45
Lysine, %	1.10	1.10	1.10	0.95	0.95	0.95	0.85	0.85	0.85
Methionine, %	0.32	0.32	0.32	0.29	0.29	0.29	0.27	0.27	0.27
Methionine & cystine, %	0.67	0.67	0.67	0.61	0.61	0.61	0.57	0.57	0.57
Threonine, %	0.78	0.78	0.78	0.70	0.70	0.70	0.64	0.64	0.64
Tryptophan, %	0.24	0.24	0.24	0.21	0.21	0.21	0.19	0.19	0.19
Calcium, %	0.80	0.80	0.80	0.80	0.80	0.80	0.70	0.70	0.70
Phosphorus, %	0.65	0.65	0.65	0.65	0.65	0.65	0.60	0.60	0.60
Energy, kcal, ME/lb	1566.82	1547.34	1527.45	1568.47	1549.03	1529.10	1575.94	1556.50	1537.07
	----------Calculated total composition----------								
U.S. $ per cwt	9.20	9.18	9.12	8.81	8.77	8.72	8.07	8.04	7.94

[a] Micro-Lite, LLC.

Table 2. Effect of Magnesium-Mica level on performance of growing-finishing pigs.[a]

Item	Magnesium-Mica, %			SEM
	0	1.25	2.50	
Starter				
ADG, lb	1.36	1.23	1.36	0.079
ADFI, lb	3.28	3.04	3.21	0.125
F:G	2.44	2.49	2.36	0.089
Grower				
ADG, lb	2.05	2.00	1.96	0.037
ADFI, lb	5.46	5.17	5.24	0.110
F:G	2.69	2.59	2.67	0.033
Finisher				
ADG, lb	2.09	2.16	2.05	0.064
ADFI, lb	6.49	6.78	6.97	0.436
F:G	3.10	3.17	3.41	0.185
Pig weight				
Initial weight, lb	59.88	59.88	59.88	0.02
Phase 1, lb	84.39	82.48	84.26	1.25
Phase 2, lb	152.33	149.42	149.89	1.96
Phase 3, lb	239.49	238.68	234.81	3.52

[a]No treatment effects were noted (P > .10).

Table 3. Effects of Magnesium-Mica on Fat-O-Meter® information and pork quality data collected at the Seaboard Farms, Inc., packing plant.

Item	Magnesium-Mica, %			SEM
	0	1.25	2.50	
Hot carcass weight, lb	177.60	173.80	182.30	132.00
10th rib fat depth, in	1.00[d]	0.83[e]	0.93[de]	0.03
10th rib loin eye depth, in	1.98	1.92	2.05	0.04
Lean muscle yields, %	49.08[g]	50.66[f]	50.04[fg]	4.85
Muscle pH	5.62	5.63	5.60	0.06
Marbling score[a]	2.17	2.07	2.01	0.35
NPPC firmness score[a]	2.45	2.16	2.49	0.40
Japanese color score[b]	4.12	4.10	4.04	0.07
Minolta CIE values[c]				
L*	52.82	52.36	52.45	17.91
a*	8.62	8.05	8.24	4.23
b*	7.30	7.04	6.86	3.41

[a] 1 = devoid to practically devoid marbling and very soft; 3 = small to modest marbling and slightly firm; and 5 = moderately abundant or greater marbling and very firm. Scores of 1 and 5 for marbling and 1 and 2 for firmness are considered unacceptable by the NPPC (1991).

[b] Six-point scale, where 1 = light and 6 = dark.

[c] L* = 0 is black and 100 is white; a* = red is positive and green is negative; and b* = yellow is positive and blue is negative.

[d,e] Within a row, means lacking a common superscript letter differ (P < .05).

[f,g] Within a row, means lacking a common superscript letter differ (P < .10).

Table 4. Effects of Magnesium-Mica on pork quality data collected at the University of Arkansas Red-Meat Abattoir.

Item	Magnesium-Mica, %			SEM
	0	1.25	2.50	
Muscle pH	5.62[g]	5.76[f]	5.60[g]	0.06
Marbling score[a]	2.22	2.25	2.22	0.40
NPPC color score[a]	2.61	2.57	2.63	0.22
Japanese color score[b]	3.03	2.97	3.10	0.26
Hunter CIE values[c]				
L*	51.32	51.66	51.38	8.63
a*	7.04[i]	6.35[h]	7.04[i]	1.48
b*	15.23[f]	14.62[g]	15.26[f]	0.80
Hue angle[d]	65.35	66.58	65.29	14.53
Saturation index[e]	16.82[f]	15.97[g]	16.83[f]	1.11
Drip loss, %	2.12	2.55	2.18	1.81

[a]1 = devoid to practically devoid marbling and pale, pinkish-gray color; 3 = small to modest marbling and reddish-pink color; and 5 = moderately abundant or greater marbling and dark purplish-red color. Scores of 1 and 5 for marbling and color are considered unacceptable by the NPPC (1991).

[b]Six-point scale, where 1 = light and 6 = dark.

[c] L* = 0 is black and 100 is white; a* = red is positive and green is negative; and b* = yellow is positive and blue is negative.

[d]Hue angle represents a change from red color (the greater the value the farther from red the muscle color).

[e]Saturation index represents the "vividness" of the color (the greater the value the more highly colored the muscle color).

[f,g]Within a row, means lacking a common superscript letter differ ($P < .05$).

[h,i]Within a row, means lacking a common superscript letter differ ($P < .10$).

Effect of Magnesium-Mica on Pork Loin Quality During Extended Refrigerated Storage[1]

Jason Apple, Jesse Davis, Lillie Rakes, Charles Maxwell, Fred Pohlman, and Brenda de Rodas[2]

Story in Brief

Boneless pork loins from 120 crossbred gilts and barrows fed diets containing 0, 1.25, or 2.50% Magnesium-Mica (MgM) were vacuum-packaged and transported to the University of Arkansas Red-Meat Abattoir. At approximately 48 hours postmortem, pork loins were fabricated into loin chops, and 0-week data were collected by trained personnel. The remaining portion of each pork loin was re-vacuum-packaged and stored at 34°F for either 4 or 8 weeks. There were no ($P > .10$) treatment x storage interactions for any pork quality trait, and inclusion of MgM in the diet had no ($P > .10$) effect on pork quality. Loins stored for 4 and 8 weeks had higher ($P < .05$) marbling scores than loins processed 48 hours after slaughter. Loin chops became lighter ($P < .05$), redder ($P < .05$), and more yellow ($P < .05$) as storage time increased from 0 to 8 weeks. The saturation index increased ($P < .05$) as storage length increased, indicating that the vividness, or purity, of the muscle color improved during storage. Loins stored for 4 and 8 weeks had higher ($P < .05$) purge and lower ($P < .05$) drip losses than loins vacuum-packaged for only 48 hours after slaughter. Length of refrigerated storage appears to improve some quality characteristics of vacuum-packaged boneless pork loins. However, inclusion of MgM in the diet prior to slaughter had no appreciable effects on pork quality during refrigerated storage.

Introduction

Supplementing finishing diets with magnesium has been shown to have positive effects on pork quality, especially muscle pH, color, and water-holding capacity (Schaefer et al., 1993; D'Souza et al., 1998). In our laboratory, Maxwell et al. (1998) included Magnesium-Mica in starter-grower and finishing diets, and showed that muscle color was improved by magnesium.

Nutritional modification of pork quality has received considerable attention in the past decade because of pork exports to Japan. The Japanese market has developed a stringent set of quality standards that must be met before a pork product can enter their country. Because the Japanese purchase fresh pork, pork is typically vacuum-packaged to maintain pork quality during transportation and refrigerated storage. It appears that magnesium-supplementation has some positive effects on pork quality; however, no information is available concerning the effect of magnesium-supplementation on pork quality during refrigerated storage. Therefore, the aim of this project was to determine the effect of Magnesium-Mica - supplemented in the growing-finishing diets of pigs - on pork quality traits during a 56-day refrigerated storage period.

Experimental Procedures

One hundred and twenty crossbred gilts and barrows were moved from the nursery unit to the University of Arkansas Swine Farm, and blocked by weight, litter and sex, and randomly allotted to 24 pens (five pigs/pen) at an average weight of 45 to 50 lb. Pigs were fed a three-phase diet with transition from starter to grower and from grower to finisher occurring when the mean weight of each block reached approximately 75 and 150 lb, respectively. A total of eight pens were randomly allotted to each of three treatments: 1) control diet (0%) that met or exceeded nutrient requirements for growing-finishing swine (NRC, 1988); 2) control diet supplemented with 25 lb of Magnesium-Mica (MgM) per ton of feed (1.25%) added at the expense of corn; and 3) control diet supplemented with 50 lb of MgM per ton of feed (2.50%) added at the expense of corn. All pigs received a standard corn-soybean meal diet formulated to contain 1.1% lysine during the starter phase, 0.95% lysine during the growing period, and 0.85% lysine during the finishing phase. When the lightest block averaged 235 lb, all pigs were transported approximately 450 miles to the Seaboard Farms, Inc., pork packing plant in Guymon, Oklahoma.

[1] The authors wish to express their appreciation to Matt Stivarius, Kathy McElyea, Levi McBeth, and Jerry Stephenson for loin fabrication and data collection, and Dr. Zelpha Johnson for statistical consultation.

[2] All authors are associated with the Department of Animal Science, Fayetteville.

After a 24-hour chilling and tempering period, pork carcasses were fabricated, and vacuum-packaged, and boneless pork loins were vacuum-packaged and shipped to the University of Arkansas Red-Meat Abattoir. Upon arrival, pork loins were removed from their vacuum-packs to collect initial quality data. The remaining portion of the pork loins were vacuum-packaged in 3 mL polyethylene-nylon vacuum bags (Koch Supplies Inc., Kansas City, Missouri; oxygen transmission rate = 0.6 cc/100 in^2/24 hours; water vapor transmission rate = 0.6 g/100 in^2/24 hours). The re-packaged loins were placed in wax-coated boxes, and stored at 34°F for either 4 or 8 weeks.

At approximately 48 hours postmortem, and after 4 and 8 weeks of storage, pork loins were removed from the vacuum-packages, blotted with paper towels, and a 2-inch portion of the loin was removed and discarded. The amount of purge (moisture) collected within the package was measured in a graduated cylinder. Two 1.5-inch thick chops were fabricated for drip loss determinations following the suspension procedure of Honikel et al. (1986). A 1.5-inch diameter core was removed from each 1.5-inch thick chop, weighed, and suspended on a fishhook (barb removed) mounted to the lid of a plastic container (18 inches deep x 15 inches wide x 24 inches long), and stored at 34°F. After 48 hours, each core was blotted with a paper towel and reweighed. The loss in weight due to drip and evaporation was divided by the original weight, multiplied by 100, and reported as drip loss percentage. Two additional 1-inch thick chops were removed from the loin, and, after a 45-minutes bloom period, U.S. (NPPC, 1991) and Japanese color scores were recorded, along with marbling scores. Also, CIE L*, a*, and b* (CIE, 1976) values were collected with a Hunter MiniScan XE (Hunter Associates Laboratory, Inc., Reston, Virginia).

Pork quality data were analyzed as a split-plot design (Gill and Hafs, 1971) using the GLM procedure of SAS (1988) with MgM level (tested by the loin within treatment mean square error) as the sole source of variation in the whole plot, and storage length, and storage length x MgM level interaction as sources of variation in the subplot. Comparisons among treatments within a given time of measurement were made only if a significant ($P < .05$) storage length x MgM level interaction was apparent. Least squares means were calculated for main effects and the interaction effect, and were separated statistically using the least significant difference procedure (SAS, 1988).

Results and Discussion

There were no significant ($P > .10$) MgM level x storage length interactions for any pork quality trait. Additionally, marbling score, NPPC and Japanese color scores, CIE values, drip loss, and purge loss were not affected ($P > .10$) by inclusion of MgM in the diet (Table 1).

The effects of refrigerated storage on pork quality attributes are presented in Table 2. Loins stored for 4 and 8 weeks had higher ($P < .05$) marbling scores than loins processed 48 hours after slaughter. Even though length of storage had no ($P > .10$) effect on Japanese color scores, U.S. color scores increased ($P < .05$) from 0 to 4 weeks, but declined ($P < .05$) from 4 to 8 weeks to values similar to 0-week chops. Both Smith et al. (1974) and Hall et al. (1980) failed to note changes in color scores for chops from vacuum-packaged loins stored up to 28 days.

Pork chop CIE L* values increased as storage time increased – indicating that the loin became lighter with extended storage. Also, chops from loins stored 8 weeks were redder ($P < .05$) and more yellow ($P < .05$) than chops from loins stored 4 weeks or 48 hours. The saturation index represents the "vividness" or "purity" of a color, and the saturation index increased ($P < .05$) as storage length increased, indicating that the vividness, or purity, of the muscle color improved during storage.

Loins stored for 4 and 8 weeks had higher ($P < .05$) purge losses than loins vacuum-packaged for only 48 hours after slaughter. This concurs with the results of Lee et al. (1985), who reported significant purge losses with extended vacuum-storage (up to 49 days) at 37.5°F. On the other hand, the 0-week samples had higher ($P < .05$) drip loss percentages than loins stored for 4 or 8 weeks, which conflicts with the findings of Weakley et al. (1986), who reported reduced moisture losses from vacuum-packaging pork loins stored for up to 28 days.

Implications

Length of refrigerated storage appears to improve several quality characteristics of vacuum-packaged boneless pork loins. Storage of loins for 8 weeks resulted in higher marbling scores and redder, more vivid colored loin chops; however, loin chop color was lighter and a greater amount of the loin weight was lost as purge. The inclusion of Magnesium-Mica in the diet prior to slaughter had no appreciable effects on pork quality during refrigerated storage.

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Table 1. Effect of Magnesium-Mica on the least squares means (± SE) for pork quality.

Item	Magnesium-Mica, %		
	0	1.25	2.50
Marbling score[a]	2.43 ± 0.11	2.46 ± 0.11	2.43 ± 0.13
U.S. color score[a]	2.63 ± 0.07	2.65 ± 0.07	2.61 ± 0.08
Japanese color score[b]	3.11 ± 0.08	2.97 ± 0.08	3.07 ± 0.09
CIE values[c]			
L*	53.01 ± 0.54	53.51 ± 0.55	53.70 ± 0.63
a*	8.24 ± 0.24	7.59 ± 0.25	8.11 ± 0.28
b*	16.71 ± 0.18	16.22 ± 0.18	16.62 ± 0.21
Saturation index[d]	18.67 ± 0.23	17.94 ± 0.24	18.52 ± 0.27
Drip loss, %	1.47 ± 0.15	1.66 ± 0.15	1.46 ± 0.17
Purge loss, mL	27.54 ± 2.43	27.69 ± 2.48	31.01 ± 2.82

[a] 1 = devoid to practically devoid marbling and pale, pinkish-gray color; 3 = small to modest marbling and reddish-pink color; and 5 = moderately abundant or greater marbling and dark purplish-red color. Scores of 1 and 5 for marbling and color are considered unacceptable by the NPPC (1991).

[b] Six-point standard, with 1 = light and 6 = dark.

[c] L* = 0 is black and 100 is white; a* = red is positive and green is negative; and b* = yellow is positive and blue is negative.

[d] Saturation index represents the "vividness" of the color (the greater the value the more highly colored the muscle color).

No treatment effects were noted (P > .10).

Table 2. Effect of refrigerated storage on least squares means (± SE) for pork quality.

Item	Storage length, week		
	0	4	8
Marbling score[a]	2.25[e] ± 0.04	2.48[f] ± 0.07	2.58[f] ± 0.07
U.S. color score[a]	2.60[e] ± 0.04	2.74[f] ± 0.06	2.55[e] ± 0.06
Japanese color score[b]	3.03 ± 0.04	3.13 ± 0.06	2.98 ± 0.06
CIE values[c]			
L*	51.55[e] ± 0.17	53.68[f] ± 0.29	54.99[g] ± 0.29
a*	6.77[e] ± 0.06	8.33[f] ± 0.10	8.85[g] ± 0.11
b*	15.02[e] ± 0.05	17.01[f] ± 0.09	17.51[g] ± 0.09
Hue angle[d]	65.85[e] ± 0.19	64.14[f] ± 0.33	63.19[f] ± 0.33
Saturation index[d]	16.52[e] ± 0.06	18.98[f] ± 0.11	19.63[g] ± 0.11
Drip loss, %	2.27[e] ± 0.11	1.51[f] ± 0.18	0.81[g] ± 0.19
Purge loss, mL	3.03[e] ± 1.85	37.85[f] ± 3.18	43.35[f] ± 3.22

[a] 1 = devoid to practically devoid marbling and pale, pinkish-gray color; 3 = small to modest marbling and reddish-pink color; and 5 = moderately abundant or greater marbling and dark purplish-red color. Scores of 1 and 5 for marbling and color are considered unacceptable by the NPPC (1991).

[b] Six-point standard, with 1 = light and 6 = dark.

[c] L* = 0 is black and 100 is white; a* = red is positive and green is negative; and b* = yellow is positive and blue is negative.

[d] Hue angle represents a change from red color (the greater the value the farther from red muscle color). Saturation index represents the "vividness" of the color (the greater the value the more highly colored the muscle color).

[e,f,g] Within a row, least squares means lacking a common superscript letter differ (P < .05).

Effect of Dietary Chromium-L-methionine on Glucose Metabolism of Growing Pigs[1]

Beth Kegley[2], Charles Maxwell[2], and Tim Fakler[3]

Story in Brief

This study evaluated the effect of chromium as chromium-L-methionine on glucose tolerance and insulin sensitivity in pigs. Pigs were fed a control diet or a diet supplemented with 400 ppb Cr as chromium-L-methionine. Twenty-eight crossbred barrows (initial BW was 62.4 lb; 14 pigs/treatment) were housed in pens (seven pigs/pen; two pens/dietary treatment) and fed their respective diets for a period of 36 or 37 days prior to the metabolic challenges and blood sampling. Pigs fed diets supplemented with chromium-L-methionine had a faster ($P < .02$) glucose clearance rate from 10 to 15 minutes after glucose infusion. There was a dietary treatment by time interaction after the insulin infusion. Pigs supplemented with chromium-L-methionine had lower ($P < .05$) plasma glucose concentrations from 45 to 120 minutes after the insulin infusion. The return to basal glucose concentration was slower for pigs that were fed diets supplemented with chromium-L-methionine. These data indicate that chromium-L-methionine was a bioavailable source of chromium. Using other bioavailable sources, chromium supplementation has been shown to increase percentage carcass lean in market hogs, and increase litter size in sows.

Introduction

Chromium was shown to be essential for normal glucose metabolism in the rat in 1959. Recent work has shown that supplementation with chromium as chromium picolinate affects glucose metabolism in the pig. Supplementation of chromium picolinate has also increased lean carcass percentage in finishing pigs, and increased litter size in sows (NRC, 1997). Presently, chromium picolinate is the only source of chromium approved by the FDA for use in swine diets. This investigation was conducted to demonstrate a metabolic effect of supplementing chromium as chromium-L-methionine to swine rations. The rate of glucose clearance after an exogenous glucose infusion and after an exogenous insulin infusion was determined.

Experimental Procedures

Twenty-eight crossbred barrows weighing 62.4 lb (55 to 61 days of age) were used. Barrows were from Duroc x Landrace x Yorkshire sows and were sired by Tyson line X boars. Pigs were blocked by weight and randomly assigned to pens (two pens/block) with seven pigs per pen, and pens within block were randomly assigned to treatment, resulting in two replicate pens per dietary treatment. Five feet by thirteen feet pens were located in a curtain sided building.

Dietary treatments included a control diet, and a diet supplemented with 400 ppb chromium. The source of chromium was chromium-L-methionine (Zinpro Corp., Eden Prairie, Minnesota). Diets exceeded the nutrient needs of the pigs based on NRC (1988) recommendations and were provided by Consolidated Nutrition. The researchers were blind to experimental treatments. Pigs were allowed *ad libitum* access to water and feed.

Pigs were fed their respective diet for 34 or 35 days. On day 35 and 36, pigs in one pen per dietary treatment were fitted with an indwelling jugular catheter. At the time of cannulation the BW of the pigs was 100.3 ± 11.9 lb. After catheterization, pigs were housed individually in 4 ft x 6 ft pens bedded with wood shavings. Pigs were allowed *ad libitum* access to water, and were offered 2 lb of feed after cannulation and 5 lb on the day between cannulation and bleeding.

Approximately 30 hours post-catheterization, the pigs were fasted for 15 to 18 hours. After the fast, the effect of chromium-L-methionine on glucose metabolism was determined by conducting an intravenous glucose tolerance test (IVGTT) followed 3 hours later by an intravenous insulin challenge test (IVICT). These tests involved glucose (500 mg glucose/2.2 lb of BW) and insulin (.1 IU insulin/2.2 lb of BW) infusions followed by serial blood sampling at -10, 0,

[1] Appreciation is expressed to Zinpro Corp. for providing financial assistance for this project.
[2] Department of Animal Science, Fayetteville
[3] Zinpro Corp., Eden Prairie, Minnesota.

5, 10, 15, 30, 45, 60, 90, and 120 minutes relative to dosing. Glucose clearance (percentage/minute) and half life were calculated for time intervals between 5 and 30 minutes for the IVGTT, and between 0 and 15 minutes for the IVICT (Kaneko, 1989).

Plasma glucose concentrations were determined using a spectrophotometric procedure in a commercially available kit (Sigma). Plasma insulin concentrations were determined using a commercially available solid phase radioimmunoassay kit (Diagnostic Products Corporation).

Data were analyzed by ANOVA using the GLM procedure of SAS (1988). The model for glucose clearance rates, half lives, and area under the curve included treatment. The model for plasma glucose after the infusions included effects of treatment, pig nested within treatment, time, and the interaction of time by treatment. The error term for treatment was pig nested within treatment. Pig was the experimental unit.

Results and Discussion

Of the twenty-eight pigs that were fed, 19 catheters were functional throughout the sampling period. There were no missing samples in this data (nine pigs on the control, and 10 pigs on the chromium supplemented diet).

Intravenous Glucose Tolerance Test. Pigs supplemented with chromium-L-methionine had lower ($P < .06$) plasma glucose concentrations before and during the IVGTT (Fig. 1). When statistically analyzed by time, pigs fed diets supplemented with chromium-L-methionine had lower plasma glucose concentrations at -10 ($P < .07$), 0, and 15 ($P < .05$) min after glucose infusion. Pigs supplemented with chromium-L-methionine had an 8.6% lower baseline plasma glucose concentration than pigs consuming the control diet. Fifteen minutes after the glucose infusion pigs supplemented with chromium-L-methionine had an 11.9% lower ($P < .05$) plasma glucose concentration than control pigs. Because pigs supplemented with chromium-L-methionine had lower baseline plasma glucose concentrations, area under the curve was not affected by treatment at any time point.

Supplemental chromium-L-methionine increased the glucose clearance rate ($P < .03$) and decreased glucose half life ($P < .02$) from 10 to 15 minutes after the glucose infusion (Table 1). However, glucose clearance rates and half-life were not significantly affected ($P > .10$) by treatment at other time points.

There was a tendency ($P < .12$) for an interaction of time by dietary treatment on plasma insulin concentrations during the glucose tolerance test (Fig. 2). When statistically analyzed within a sampling time, plasma insulin concentration was lower ($P < .02$) before the glucose tolerance test for pigs fed the diet supplemented with chromium-L-methionine. The area under the insulin curve (Table 1) also tended ($P < .14$) to be smaller from 0 to 120 minutes after the glucose infusion for pigs fed the diet supplemented with chromium-L-methionine.

Intravenous Insulin Challenge Test. There was a significant interaction of time by dietary treatment on plasma glucose concentrations ($P < .02$) during the insulin infusion (Fig. 3). There was a tendency for supplemental chromium-L-methionine to increase ($P < .12$) glucose clearance rate from 5 to 15 minutes after the insulin infusion (Table 2). Pigs that were fed diets supplemented with chromium-L-methionine had lower ($P < .05$) plasma glucose concentrations from 45 to 120 minutes after insulin infusion than did pigs fed the control diet. Pigs supplemented with chromium-L-methionine had 20, 21, 19, and 15% lower plasma glucose concentrations at 45, 60, 90, and 120 minutes after infusion as compared to the pigs fed the control diet. Therefore, area under the curve was greater ($P < .03$) for the pigs fed diets supplemented with chromium-L-methionine. The return to basal glucose concentration was more gradual for pigs that were fed diets supplemented with chromium-L-methionine. Tissues from these pigs that were fed supplemental chromium-L-methionine might have been more sensitive to the insulin, or the insulin might have had a longer lasting effect in these pigs.

There were no effects of supplementing chromium-L-methionine on plasma insulin concentrations after the insulin infusion (Fig. 4). However, immediately before the infusion, pigs fed supplemental chromium-L-methionine had a lower ($P < .05$) concentration of plasma insulin.

In summary, chromium-L-methionine supplementation increased the sensitivity of pigs to an insulin challenge. Supplementation with chromium-L-methionine also increased the glucose clearance rate from 10 to 15 minutes during a glucose tolerance test.

Implications

Through altering glucose and insulin metabolism, this study demonstrated that chromium-L-methionine is a bioavailable chromium source for growing pigs. Research with other chromium sources has shown that chromium supplementation increases the percentage carcass lean in market hogs, and increases the number of pigs born to sows.

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Table 1. Effect of dietary chromium-L-methionine on glucose and insulin metabolism after an intravenous glucose tolerance test (mean ± SE).

Item	Supplemental Cr level, ppb 0	400	P value
Number of pigs	9	10	
Glucose			
Clearance, %/min			
10 to 15 min	3.34 ± 0.334	4.50 ± 0.317	0.03
15 to 30 min	4.14 ± 0.405	4.52 ± 0.384	0.50
Half life, min			
10 to 15 min	21.7 ± 1.50	16.4 ± 1.43	0.02
15 to 30 min	17.3 ± 1.56	16.9 ± 1.48	0.85
Insulin			
Area under the curve, μIU of plasma insulin/ml * min			
0 to 120 min	1,000 ± 187	590 ± 178	0.14

Table 2. Effect of dietary chromium-L-methionine on glucose and insulin metabolism after an intravenous insulin challenge test (mean ± SE).

Item	Supplemental Cr level, ppb 0	400	P value
Glucose			
Area under the curve, mmol of plasma glucose/L * min			
0 to 120 minutes	-150 ± 13	-200 ± 12	0.02
Clearance, %/minutes			
0 to 15 min	8.05 ± 0.627	9.29 ± 0.595	0.17
5 to 15 min	9.09 ± 0.839	10.99 ± 0.796	0.12
Half life, min			
0 to 15 min	8.8 ± 0.54	7.8 ± 0.51	0.21
5 to 15 min	7.8 ± 0.52	6.8 ± 0.50	0.16
Insulin			
Area under the curve, μIU of plasma insulin/ml * min			
0 to 120 min	1600 ± 177	1760 ± 168	

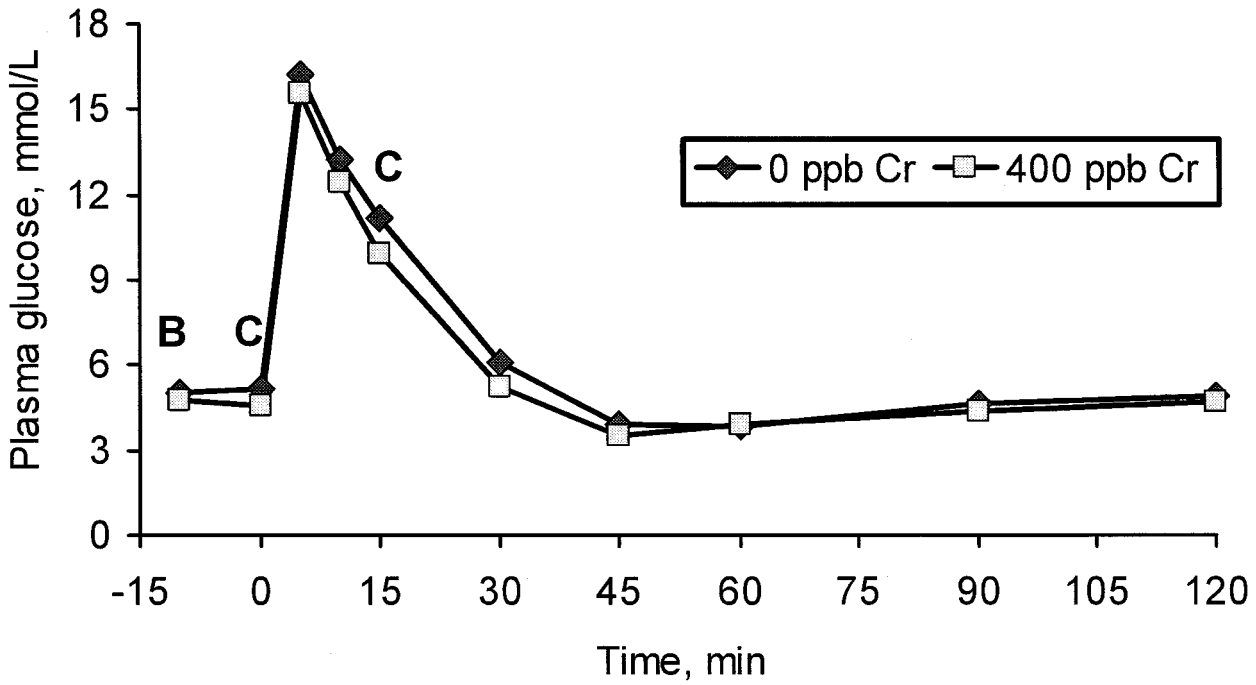

Fig. 1. Effect of dietary chromium-L-methionine on glucose metabolism after an intravenous glucose tolerance test.[A]

[A] Effect of dietary treatment for all sampling times (P<.06).
[B] Effect of dietary treatment (P<.07).
[C] Effect of dietary treatment (P<.05).

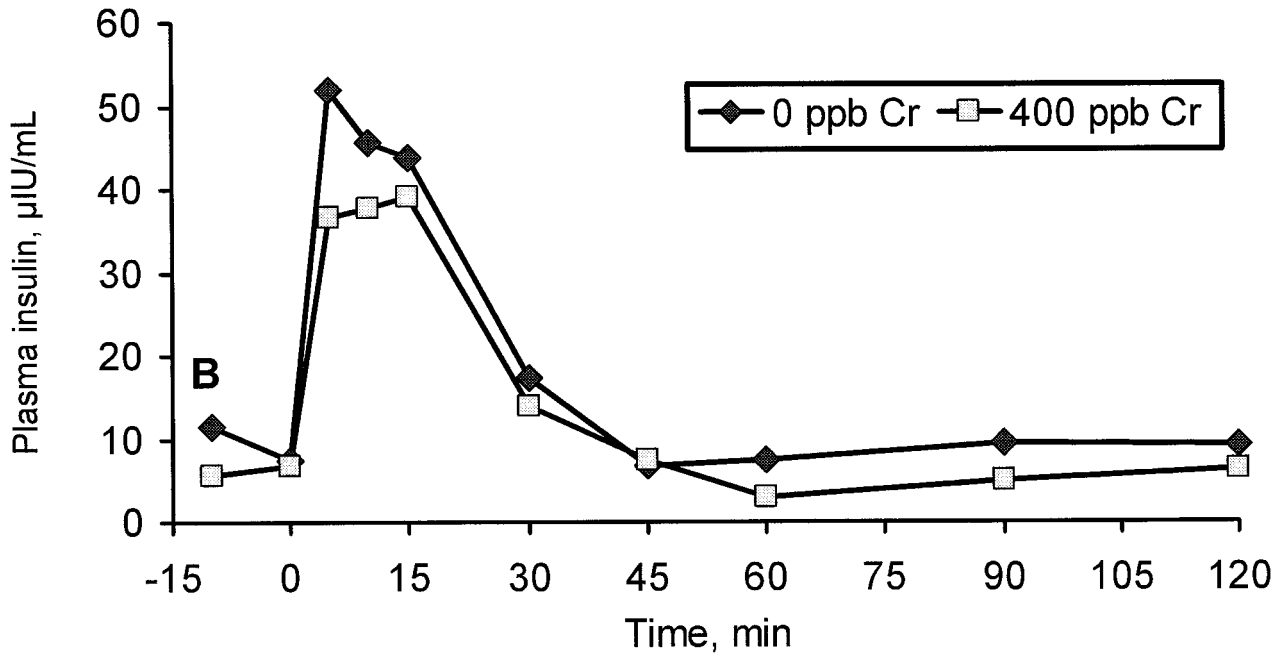

Fig. 2. Effect of dietary chromium-L-methionine on insulin metabolism after an intravenous glucose tolerance test.[A]

[A] Interaction of time by dietary treatment (P<.12).
[B] Effect of dietary treatment (P<.02).

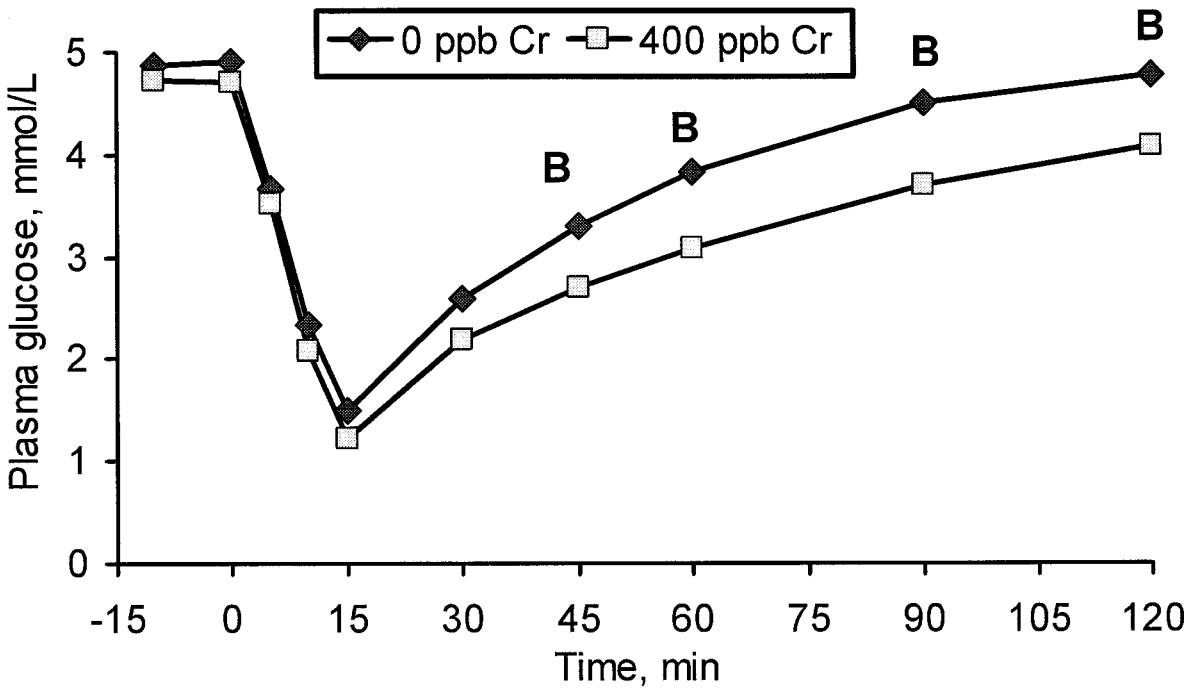

Fig. 3. Effect of dietary chromium-L-methionine on glucose metabolism after an intravenous insulin challenge test.[A]

[A] Interaction of time by dietary treatment (P<.02).
[B] Effect of dietary treatment (P<.05).

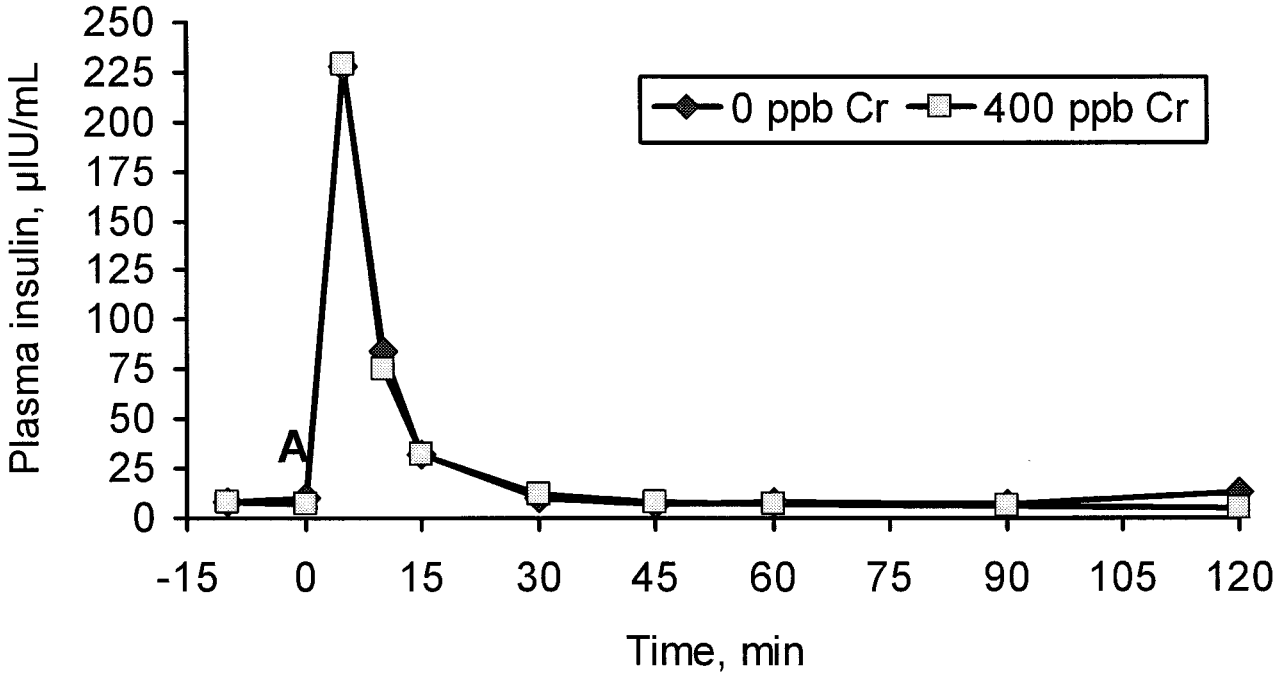

Fig. 4. Effect of dietary chromium-L-methionine on insulin metabolism after an intravenous insulin challenge test.

[A] Effect of dietary treatment (P<.05).

Estimation of Litter Environmental and Maternal Effects for Performance Test Traits of Large White Swine

Zelpha Johnson[1], Jeff Chewning[2], and Russ Nugent, III[2]

Story in Brief

The objective of this study was to investigate the importance of litter environmental effects, maternal genetic effects, and the covariance between additive genetic effects of the animal and maternal genetic effects for performance test traits for a population of purebred Large White swine. Boars were individually penned at approximately 100 days of age and fed a corn-soybean meal diet for approximately 77 days. Weights and feed intake were recorded. Backfat and loin eye area were measured over the 12th rib at the end of the test using B-Mode ultrasound equipment. Daily feed intake, feed:gain ratio and ADG were calculated. Data were available for years 1990 to 1997. Four models were examined. Model 1 included only the additive genetic effect of the animal; Model 2 added the common litter environmental effect; Model 3 added the maternal genetic value assumed to be uncorrelated with the additive genetic effect. Model 4 was the same as Model 3 with additive and maternal genetic effects assumed to be correlated. Ratios of likelihoods were used to compare models. Common litter environmental effects were important ($P < .01$) for all traits measured and explained from 13 to 40% of the phenotypic variation. The maternal genetic value and the correlation between maternal and direct genetic effects were important sources of variation for some traits but had little effect on the estimation of heritability.

Introduction

Mixed-model procedures have become the method of choice for estimating breeding values of animals. They provide best linear unbiased predictors (BLUP) of breeding values, and also simultaneously estimate genetic and environmental effects, taking into account relationships among animals. It is important to have accurate estimates of variance components for any random effects that may be included in the model. Maternal effects, if present, may present an obstacle to genetic improvement of traits. Although these effects are strictly environmental with respect to offspring, they can have both environmental and genetic components with respect to the dam. Maternal additive genetic effects, if present, may bias estimates of direct additive genetic effects because both are transmitted from one generation to the next. Therefore, maternal effects, if important in the population for a trait, should be included in the evaluation model. It is also important to identify relationships of maternal effects with direct effects. For litter bearing species, common litter environmental effects for some traits may be important. Thus, identification of the most appropriate model for subsequent calculations of breeding values is important.

The objective of this study was to determine the importance of litter environmental effects and maternal genetic effects, as well as the correlation between maternal genetic effects and random animal genetic effects, for performance traits of Large White boars.

Materials and Methods

Data evaluated were performance test records from Large White boars from a commercial swine operation from 1990 to 1997. Boars born to approximately 60% of the litters were culled at weaning based on a maternal breeding value (index) for the dam. These index values were based on number born alive, farrowing interval, and weaning weight of the dam. Boars that were not culled were grown to 100 days of age. At this time, boars to be individually pen tested were selected primarily on phenotypic weight, with some consideration given to the maternal index.

Boars to be performance tested were individually penned in 2.79 m^2 pens on slatted concrete floors at approximately 100 days of age (79 to 134 days; mean = 100.4 days) for approximately 77 days. A pelleted corn-soybean meal diet formulated to contain 1.14% lysine, 19% protein, and 3,344 kcal/kg ME was offered *ad libitum*. Exact composition of the diet varied due to ingredient cost. Ending test age ranged from 156 to 211 days, with a mean of 176.2 days. Boars (n = 7,722) were weighed at the beginning (WT100) and end of

[1] Department of Animal Science, Fayetteville.
[2] The Pork Group, Rogers.

the test (WT177), and feed intake was recorded. Boars were typically fed three to four times a week; however, feed was only weighed back at the end of the test. Backfat (n = 7,715) and loin eye area (LEA; n = 7,711) were measured at the 12th rib upon completion of the test using B-Mode ultrasound equipment. Backfat was measured 4 cm off the midline with skin excluded. Average daily gain (ADG; n = 7,711), average daily feed intake (ADFI; n = 7,541) and feed:gain ratio (F:G; n = 7,541) were calculated.

Variance components and genetic parameters for each trait were estimated by four animal models using MTDFREML (Boldman et al., 1993; Boldman and Van Vleck, 1991). Model 1 included only the additive genetic effect of the animal (d), Model 2 included (d) and the common litter environmental effect, Model 3 included (d), the maternal genetic value (m), assumed to be uncorrelated with d, and the common environmental effect, and Model 4 was the same as Model 3, but with d and m assumed to be correlated. In all models, the convergence criterion (i.e., variance of the simplex values) for all runs was 10^{-9}. All analyses included pedigrees back to 1990 giving 92,145 animals in the relationship matrix. Fixed effects were contemporary groups (defined by month test started and barn of origin; boars originated from four barns) and initial test age as a covariate. There were 339 contemporary groups, and number of observations in a contemporary group ranged from 8 to 204 (mean = 77).

Genetic parameters estimated were direct additive heritability (h^2_d), maternal heritability (h^2_m), the correlation between **d** and **m** ($r_{d,m}$) and total heritability (Ferraz and Johnson, 1993; $h^2_t = [\sigma^2_d + .5\sigma^2_m + 1.5\sigma(\mathbf{d},\mathbf{m})]/\sigma^2_p$, where σ^2_d is the estimate of variance for direct genetic effects, σ^2_m is the estimate of variance for maternal genetic effects and $\sigma(\mathbf{d},\mathbf{m})$ is the estimate of covariance between direct and maternal genetic effects and σ^2_p is the estimate of phenotypic variance). The ratio of variance of common environmental effects associated with the litter (c^2) to σ^2_p was also estimated.

The method described by Ferraz and Johnson (1993) to calculate ratios of likelihoods was used to compare models. The ratio $-2[\log \Lambda_i - \log \Lambda_j]$ is asymptotically distributed as chi-square with degrees of freedom equal to the difference in the number of parameters in the Models i and j, where Λ is the value of the likelihood function for the model, after the convergence criterion was reached.

Results and Discussion

A property of these methods of analysis is that the larger the value of the likelihood function, the better the model explains the variation in the data. When a parameter is added to an analysis, the value of the likelihood function should increase, and the likelihood ratio test can be used to test significance of the changes in the likelihoods. Results of these tests are presented in Table 1.

For all traits examined, significantly larger likelihood values were obtained when Model 2 was used compared with Model 1 indicating that permanent environmental litter effects were important for all traits. For WT100, LEA and WT177, significantly larger likelihoods were obtained when Model 3 was compared to Model 2 indicating that maternal genetic effects were important for these traits. Generally, larger likelihoods were not obtained for Model 4 when compared to Model 3 indicating that including the correlation between direct and maternal genetic effects did not add significant information. Exceptions were backfat and WT177 where the correlation between direct and maternal genetic effects did provide significant information.

Estimates of genetic, environmental, and phenotypic parameters obtained from each model are presented in Table 2. Estimates from all models are presented for comparison purposes, although the estimates most appropriate for backfat and WT177 would be those from Model 4. Estimates most appropriate for WT100 and LEA would be those from Model 3, and for ADG, ADFI and F:G, estimates from Model 2 would be most appropriate.

Estimates of environmental litter effects (c^2) ranged from .13 for backfat to .40 and .37 for WT100. Within a trait these estimates were similar for all models. Even though statistically significant for three traits, estimates of h^2_m were low for all traits ranging from 0 to .06. The estimates of heritability of direct genetic effects (h^2_d) for all traits decreased when environmental effects of litters were introduced from Model 1 to Model 2, but generally the addition of maternal effects in Models 3 and 4 did not cause important changes in the estimates of this parameter. Exceptions are that h^2_d for WT100 declined from .20 to .15 from Model 2 to Model 4; however, total h^2 only declined from .20 to .17. Estimates of h^2_d for backfat increased from .36 to .43 from Model 2 to Model 4; however total h^2 stayed constant at .36. All estimates of the correlation between direct and maternal effects were negative ranging from -.11 for WT100 to -.64 for F:G; however addition of these effects was only important for backfat and WT177. Although statistically significant, these values had little effect on the estimation of total heritability for backfat. Total heritability did decline from .25 for Model 2 to .19 for Model 4 for WT177 indicating that this correlation is more important for this trait.

In conclusion, environmental litter effects are important in the estimation of genetic parameters of performance test data in this population of Large White swine and should be included in any genetic evaluation program. For practical purposes, both maternal effects and the correlation between maternal and direct effects could be ignored for most other traits examined, with the possible exception of WT177.

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Table 1. Values of the differences between the likelihood functions of two different animal models[a] to test the difference between models for performance test traits of Large White boars.

Trait	Model 1 – Model 2	Model 2 – Model 3	Model 3 – Model 4
Weight at 100 d, kg	575.63**	13.48**	.17
Average daily gain, kg	103.00**	0	2.39
Average daily feed intake, kg	154.43**	2.39	1.52
Feed:gain	185.71**	1.35	3.08
Backfat, cm	62.56**	.82	4.48*
Loin eye area, cm^2	102.29**	5.29*	.76
Weight at 177 days, kg	162.76**	4.08*	7.24**

[a]Asymptotically distributed as chi-square with 1 degree of freedom.
* P < .05.
** P < .01.

Table 2. Estimates of genetic parameters obtained from Model 1 through Model 4 for performance test traits of Large White boars.

Parameter[a]	Model 1	Model 2	Model 3	Model 4
Weight at 100 days, kg				
h^2_d	.50	.20	.15	.15
h^2_m			.06	.07
$r_{d,m}$				-.11
c^2		.40	.37	.37
h^2_t	.50	.20	.18	.17
Average daily gain, kg				
h^2_d	.36	.24	.24	.26
h^2_m			0	.03
$r_{d,m}$				-.46
c^2		.18	.18	.18
h^2_t	.36	.24	.24	.21
Average daily feed intake, kg				
h^2_d	.38	.23	.22	.24
h^2_m			.01	.02
$r_{d,m}$				-.40
c^2		.22	.22	.22
h^2_t	.38	.23	.22	.21
Feed:gain				
h^2_d	.29	.16	.15	.18
h^2_m			0	.01
$r_{d,m}$				-.64
c^2		.26	.26	.26
h^2_t	.29	.16	.15	.14

continued

Table 2. Continued.

Parameter[a]	Model 1	Model 2	Model 3	Model 4
Backfat, cm				
h^2_d	.46	.36	.36	.43
h^2_m			.00	.02
$r_{d,m}$				-.59
c^2		.13	.13	.13
h^2_t	.46	.36	.36	.36
Loin eye area, cm^2				
h^2_d	.33	.24	.24	.26
h^2_m			0	.02
$r_{d,m}$				-.33
c^2		.18	.18	.18
h^2_t	.33	.24	.24	.23
Weight at 177 days, kg				
h^2_d	.40	.25	.22	.26
h^2_m			.03	.09
$r_{d,m}$				-.49
c^2		.22	.21	.20
h^2_t	.40	.25	.24	.19

[a] h^2_d is direct additive heritability, h^2_m is maternal heritability, $r_{d,m}$ is the correlation between direct and maternal effects, c^2 is the proportion of the variance associated with common litter environmental effects, and h^2_t is the total heritability of the trait.

Genetic Parameters for Production Traits and Measures of Residual Feed Intake in Large White Swine

Zelpha Johnson[1], Jeff Chewning[2], and Russ Nugent, III[2]

Story in Brief

The purpose of this study was to estimate genetic parameters for ADG, backfat thickness, loin eye area, and measures of feed intake and efficiency for purebred Large White boars born from 1990 to 1997. Boars were individually pen tested for approximately 77 days starting at 100 days of age. Daily feed intake, ADG, and feed:gain ratio were computed. Four measures of residual feed intake were estimated as the difference between actual feed intake and that predicted from models that included various other performance test traits. Genetic parameters were estimated using a model that included fixed effects of contemporary groups and initial test age as a covariate and random animal and litter effects. Heritability estimates for test ADG, daily feed intake, feed:gain, backfat, loin eye area, and the four measures of residual feed intake were .24, .23, .16, .36, .24, .17, .11, .15, and .10, respectively. Genetic correlations indicated that selection for reduced residual feed intake could be made without adversely affecting ADG. Backfat should also decrease, and loin eye area should increase. The amount of change in backfat or loin eye area would depend on the measure of residual feed intake used.

Introduction

Feed costs represent a major portion of the total cost of swine production. Individual animals differ in their ability to efficiently use feed. Selecting the most efficient animals may significantly lower production costs. Direct selection for genetic improvement in feed efficiency, however, has not been widely practiced for a number of reasons. It is difficult to measure for individual pigs and results in high labor and equipment costs. Direct selection for feed efficiency has not always been effective, and may not be the best way to improve this trait because of complex additive and multiplicative relations. This may be partly due to the fact that feed efficiency is not a directly measurable trait; it is usually computed as the ratio of feed intake to product produced. An alternative measure for expressing feed efficiency is residual feed intake, which measures feed intake adjusted for energy requirements for maintenance and production and, by definition, has zero phenotypic correlation with these traits. Variation in this measure may reflect differences in the efficiency with which animals digest and use energy for maintenance and production. Inclusion of this trait in a breeding program depends on its heritability and its relationships with other traits of interest.

The objectives of this study were to estimate genetic parameters for ADG, backfat, and loin eye area and several measures of residual feed intake for a population of Large White swine and to examine genetic and phenotypic relationships of residual feed intake to these production traits.

Materials and Methods

Data evaluated were performance test records from Large White boars collected in a commercial swine operation from 1990 to 1997. Boars born to approximately 60% of the litters were culled at weaning based on a maternal breeding value (index) for the dam. These index values were based on number born alive, farrowing interval, and weaning weight. Boars that were not culled were grown to 100 d of age. At this time, boars to be individually pen tested were selected primarily on phenotypic weight, with some consideration given to the maternal index.

Boars were individually penned in 2.79 m^2 pens on slatted concrete floors at approximately 100 days of age (79 to 134 days; mean = 100.4 days) for approximately 77 days. They were fed for *ad libitum* consumption a pelleted corn-soybean meal diet that was 1.14% lysine, 19% protein, and 3,344 mcal/kg ME. Exact composition of the diet varied due to ingredient cost. Ending test age ranged from 156 to 211 days, with a mean of 176.2 days. Boars were weighed at the beginning and end of the test and feed intake was recorded. Boars were typically fed three to four times a week; however, feed was only weighed back at the end of the test. Backfat and loin eye area (LEA) were measured at the 12th rib at the end of the test using B-Mode ultrasound equipment. Backfat was measured 4 cm off the midline with skin excluded. Average daily gain (ADG), average daily feed intake (ADFI), and feed:gain ratio (F:G) were calculated. Number of records was 7,722 for ADG, 7,542 for ADFI and F:G,

[1]Department of Animal Science, Fayetteville
[2]The Pork Group, Rogers

7,716 for backfat, and 7,712 for LEA.

Heritabilities and genetic correlations were estimated using the MTDFREML program of Boldman et al. (1993) and Boldman and Van Vleck (1991) using single- and multiple-trait analyses. All analyses included pedigrees back to 1990 giving 92,145 animals in the relationship matrix. Models included fixed effects of contemporary groups (defined by month test started and barn of origin; boars originated from four barns) and initial test age as a covariate, as well as random litter and animal effects. Preliminary analyses of performance test data indicated that maternal effects were not important; therefore, they were not included in the reported analyses.

In this type of analysis, it is important that contemporary groups be connected. That is, sires should be used in more than one contemporary group, and contemporary groups should represent more than one sire. In the population from which these boars were selected, there were 339 contemporary groups, with number of observations in a contemporary group ranging from 8 to 204 (mean = 77). There were 9,076 litters from 713 sires. Ninety-seven of the sires were used in more than one barn. The frequency distribution for number of litters sired by each sire is shown in Table 1. While 177 of the 713 sires represented in this data set only had one litter represented, over half the sires had more than seven litters. As another check on connectedness, frequency distributions for number of contemporary groups in which a sire was represented and number of sires represented in a contemporary group are given in Table 2. For example, 63 sires were represented in more than 15 contemporary groups. Number of sires in a contemporary group ranged from two to more than 25. Ten contemporary groups had more than 25 sires represented.

Four measures of residual feed intake were estimated as the difference between actual feed intake and that predicted from single-trait analyses for ADFI, with various combinations of production traits included as covariates. These analyses included the contemporary group effect and random animal effects, but not litter effects. Mrode and Kennedy (1993) used a similar procedure to estimate measures of residual feed intake. Model 1 included covariates of initial test age, initial test weight, and ADG (RFI1); Model 2 included initial test age, initial test weight, ADG, and backfat (RFI2); Model 3 included initial test age, initial test weight, ADG, and loin eye area (RFI3); and model 4 included initial test age, initial test weight, ADG, backfat, and loin eye area (RFI4). Including a covariate in the analysis of a trait adjusts that trait for the covariate. Thus, for example, in Model 1, feed intake is adjusted for initial test age, initial test weight and test ADG, with the assumption that this adjusted measure of feed intake (residual feed intake) will reflect differences in feed intake above what is needed for maintenance (test weight) and production (ADG). Regression coefficients from these single-trait analyses were used to estimate measures of residual daily feed intake (RFI1 to RFI4) for each pig to be used in multiple-trait analyses. As an example of how this is done, predict (or estimate) ADFI for each pig for model 1, using the equation ADFI = b0 + b1(initial test age) + b2(initial test weight) + b3(ADG) and calculate ADFI. The regression coefficients, b0, b1, b2, and b3 come from the analysis described above and initial test age, initial test weight and ADG are the actual observed values for each pig. This is the ADFI that is estimated to be necessary for maintenance and gain at this age, weight and ADG. The difference between this predicted ADFI and the actual ADFI of each pig would be RFI1. Measures for RFI2, RFI3, and RFI4 are obtained similarly, with the production traits of backfat and loin eye area being added one at a time or together.

Results and Discussion

Phenotypic average initial test weight was 117 lb. Over the years included in this study, boars gained an average of 2.20 lb a day and ate an average of 5.95 lb of feed a day. Results of analyses for single-trait models for performance and feed conversion traits are in Table 3. Several estimates of heritability for each trait were obtained through the various analyses. There were nine different estimates for ADG, backfat, and LEA, and four for ADFI, F:G, and the measures of RFI. Heritability estimates did not differ by more than 1% for any of these analyses; therefore, results of the single-trait analyses are reported for simplicity. Heritabilities of ADG, backfat, and LEA were .24, .36, and .24, respectively. Heritability of ADFI was .23. Estimates of heritability of residual DFI measures were similar to those for F:G (.16; Table 3), ranging from .10 to .17. Measures of residual DFI that included backfat had lower estimates of heritability than those without backfat included (RFI2 and RFI4 vs RFI1 and RFI3).

Litter effects were significant sources of variation for all traits examined with the proportion of phenotypic variation accounted for by litter effects ranging from .13 to .26 (Table 3). Estimates of heritability with litter effects in the model were around 10% lower than those obtained with only random animal effects in the model (Johnson, et al., 1998). Feed conversion, growth, and feed intake are interrelated, and no single character can be fully understood without consideration of the others. Genetic (r_g) and phenotypic (r_p) correlations among production traits and measures of feed conversion are in Table 4. Unfavorable genetic (.37) and phenotypic correlations (.46) were found between ADG and backfat, implying that as ADG increases so does backfat. Loin eye area was positively associated with ADG (r_g = .36) and negatively associated with backfat (r_g = -.27). Both ADG and backfat were genetically correlated with ADFI (r_g = .82 and .64, respectively), although LEA was not. Phenotypic correlations were slightly lower, being .72 for ADG with ADFI and .57 for backfat and ADFI. Thus, faster growing boars had greater daily feed intakes; so did fatter boars. The feed:gain ratio was negatively correlated with ADG (r_g = -.32) and positively correlated to backfat (r_g = .40); thus, ADG and backfat were both favorably related genetically with F:G. Loin eye area had a negative genetic correlation (-.52) with F:G, implying that boars with larger LEA were more effi-

cient. Lower correlations were found between backfat and LEA (r_g = -.27 and r_p = .04).

Estimates of genetic and phenotypic correlations between production traits and measures of residual daily feed intake are in Table 5. Genetic correlations between ADG and residual daily feed intake were small and positive (.11 to .18). Backfat was genetically correlated with residual feed intake, particularly when residual feed intake was not adjusted for backfat (.67 for RFI1 and RFI3). Correlations were all positive, however, indicating that selection for decreased residual feed intake would result in decreased backfat. Negative genetic correlations were found between loin eye area and all measures of residual ADFI, with estimates being higher for measures of residual feed not adjusted for backfat (-.51 with RFI1 and -.48 with RFI3 vs. -.31 with RFI2 and RFI4). As expected, phenotypic correlations between ADG and measures of residual feed intake were near zero (estimates of zero; Table 5) because residuals from the population regression are uncorrelated with all variables in the regression. Likewise, RFI would be uncorrelated with backfat when it is in the model and with LEA when it is in the model. However, backfat was phenotypically correlated with RFI1 (.33) and RFI3 (.32), and phenotypic correlations of loin eye area with RFI1 and RFI2 were low and negative.

In summary, faster-gaining boars had a tendency to eat more (r_g = .82) and, when one looks at gross feed efficiency, were more efficient (r_g = -.32). The fatter boars also ate more (r_g = .64) but were less efficient (r_g = .40). Relationships of ADG with residual feed intake, however, were low (.11 to .18). Genetic correlations of backfat with measures of RFI were positive, and genetic correlations of loin eye area with measures of RFI were negative. These correlations varied depending on whether RFI was adjusted for backfat.

Implications

Results of this study indicate that residual feed intake is low to moderately heritable and should respond to selection. Genetic correlations indicate that it should be possible to select for reduced residual feed intake without adversely affecting average daily gain. Backfat should also decrease, and loin eye area should increase. The amount of change in backfat or loin eye area would depend on which measure of residual feed intake is used.

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Table 1. Frequency distribution for number of litters per sire.[a]

Number of litters/sire	Number of sires
1	177
2	36
3	35
4	28
5	31
6	17
7	16
8	27
9	13
10	16
11	22
12	18
13	14
14	17
15	18
16	10
17	10
18	10
19	21
20	13
21	19
22	13
23	14
24	9
25	9
26-30	33
31-35	18
36-40	13
41-45	13
46-50	11
> 50	12

[a] For example, 177 sires had only one litter, 36 sires had two litters, etc. Twelve sires had more than 50 litters.

Table 2. Frequency distributions for number of contemporary groups in which a sire was represented and for number of sires represented in a contemporary group.

Number of contemporary groups in which a sire was represented[a]		Number of sires represented in a contemporary group[b]	
Contemporary group classification	Number of sires represented	Number of sires classification	Number of contemporary groups
1	189	1-3	4
2	54	4	3
3	53	5	6
4	40	6	7
5	33	7	11
6	31	8	20
7	31	9	25
8	40	10	23
9	39	11	28
10	31	12	22
11	15	13	24
12	29	14	16
13	28	15	14
14	18	16	14
15	19	17	15
16-20	31	18	24
21-25	18	19	25
26-30	8	20	20
>30	6	21	16
		22	9
		23	6
		24	5
		25	6
		> 25	10

[a] For example, 189 sires were represented in only one contemporary group, 54 sires were represented in two contemporary groups, etc. Six sires were represented in more than 30 contemporary groups.

[b] For example, four contemporary groups had < 4 (1 to 3) sires represented, three contemporary groups had four sires represented, etc. Ten contemporary groups had > 25 sires represented.

Table 3. Results of analyses of single trait models with initial test age as a covariate.

Trait	Heritability estimate (h^2)	Litter variance relative to phenotypic variance (c^2)
ADG	.24	.18
Daily feed intake	.23	.22
Feed:gain	.16	.26
Backfat	.36	.13
Loin eye area	.24	.18
Residual feed intake 1[a]	.17	.26
Residual feed intake 2[b]	.11	.26
Residual feed intake 3[c]	.15	.26
Residual feed intake 4[d]	.10	.26

[a] Adjusted for initial test age and weight and test ADG.
[b] Adjusted for initial test age and weight, test ADG and backfat.
[c] Adjusted for initial test age and weight, test ADG and loin eye area.
[d] Adjusted for initial test age and weight, test ADG, backfat and loin eye area.

Table 4. Estimates of genetic (r_g) and phenotypic (r_p) correlations between performance and feed conversion traits.

Trait	ADG		Backfat		Loin eye area	
	r_g	r_p	r_g	r_p	r_g	r_p
Backfat	.37	.46				
Loin eye area	.36	.31	-.27	.04		
Average daily feed intake	.82	.72	.64	.57	.00	.18
Feed:gain	-.32	-.39	.40	.14	-.52	.16

Table 5. Estimates of genetic (r_g) and phenotypic (r_p) correlations between measures of residual daily feed intake and performance traits.

Residual daily feed intake	ADG		Backfat		Loin eye area	
	r_g	r_p	r_g	r_p	r_g	r_p
Residual feed intake 1[a]	.11	.01	.67	.33	-.51	-.10
Residual feed intake 2[b]	.17	.01	.22	.02	-.31	-.05
Residual feed intake 3[c]	.12	.01	.67	.32	-.48	-.03
Residual feed intake 4[d]	.18	.01	.20	.02	-.31	-.01

[a] Adjusted for initial test age and weight and test ADG.
[b] Adjusted for initial test age and weight, test ADG and backfat.
[c] Adjusted for initial test age and weight, test ADG and loin eye area.
[d] Adjusted for initial test age and weight, test ADG, backfat and loin eye area.

Effect of Timing of Artificial Insemination on Gender Ratio in Beef Cattle

Rick W. Rorie and Toby D. Lester[1]

Story In Brief

A study was carried out to determine effect of timing of insemination on the gender of offspring in cattle. The estrous cycles of Angus heifers (n = 41) and cows (n = 98) were synchronized and a HeatWatch® electronic estrus detection system was used to monitor for onset of estrus. Animals were artificially inseminated at approximately 20 or 10 hours before expected ovulation. Sixty to 80 days after insemination, ultrasonography was used to confirm pregnancy status and to determine the gender of fetuses. Twenty-nine of 41 heifers and 69 of 98 cows were detected in estrus after synchronization and were inseminated, with 20 of 29 heifers and 48 of 69 cows subsequently confirmed pregnant. Neither the length of estrus nor intensity (number of mounts) affected pregnancy rate or gender ratio ($P \geq 0.42$). Timing of insemination had no effect on gender ratio ($P = 0.88$). No differences ($P = 0.49$) were detected in the gender ratios resulting from different sires or semen batches. In contrast to a previously reported study, our results indicate inseminating beef cattle at approximately 20 or 10 hours before expected ovulation does not alter the gender ratio of the resultant calves.

Introduction

Numerous efforts have been directed toward developing procedures for preselecting the gender of offspring. Recently, Wehner et al. (1997) reported that timing of insemination could be used to alter the gender ratio in cattle. In their study, cows were inseminated either early or late in relation to onset of estrus (estimated as 20 ± 3 and 10 ± 2 hours before ovulation, respectively). The authors reported that the early inseminations resulted in mostly heifer calves and late inseminations resulted in mostly bull calves. If timing of insemination can be used to alter the gender of offspring in cattle, it could have a substantial economic impact and practical application to the beef and dairy industries. Therefore, the objective of the present study was to further investigate the effect of timing of insemination in relation to onset of estrus and ovulation on the gender ratio of offspring in beef cattle.

Experimental Procedures

Forty-one nulliparous purebred Angus heifers and 98 Angus cows (parity 1 to 7) were used for this study. The animals were owned and maintained by a local producer-cooperator. The cows were 45 to 60 days postpartum, and all animals had a body condition score (BCS) of 6 to 7. The heifers were synchronized by feeding 0.5 mg/head/day of melengestrol acetate (MGA) for 16 days. Seventeen days after MGA withdrawal, heifers were given an injection of PGF2alpha (Lutalyse®). The cows were synchronized by treatment with GnRH (Cystroelin®) followed 7 days later by PGF2alpha treatment.

A HeatWatch® electronic estrus detection system was used to continuously monitor cows and heifers for onset of estrus, based on mounting activity. Patches containing mount detection transmitters were placed on all animals at the time of PGF2alpha injection. Onset of estrus was presumed to occur when three or more mounts (each of a duration of 1 second or more) were detected within a 4-hour period. Based on a study by Looper et al. (1998), it was assumed that ovulation would occur approximately 32 hours after the onset of estrus. In order to time inseminations approximately 20 or 10 hours before ovulation, animals were artificially inseminated at either 8 to 10 hours (early group) or 20 to 25 hours (late group) after the onset of estrus. An experienced technician performed all inseminations. Sire selection for each mating was predetermined by the producer-cooperator. Sire and semen lot or freeze date were recorded for each breeding in order to later determine any effect on gender ratio. After insemination, mount detection transmitters were removed from the cows and heifers. Starting 18 days post-insemination, animals were visually observed twice daily for return to estrus.

At 60 to 80 days of gestation, ultrasonography was performed on all animals by an experienced technician, to confirm pregnancy status and to determine gender of fetuses. Fetal size (crown to rump length) was used to confirm fetal age. The gender of fetuses was determined by identification

[1]Both authors are associated with the Department of Animal Science, Fayetteville.

of the fetal prepuce and/or scrotum, or the absence of these structures and the presence of a vulva. Breeding dates and gender of calves were subsequently confirmed at calving. Data on pregnancy status and gender were analyzed using a generalized linear model with probit link function. Included as variables in the model were parity (cows vs. heifers), time of insemination, sire or semen batch, length of estrus and intensity (mounting activity) of estrus.

Results and Discussion

Twenty-nine of 41 (70.7%) heifers and 69 of 98 (70.4%) cows were detected in estrus within 5 days of synchronization treatment and were inseminated. The pregnancy rate was similar for heifers and cows (P = 0.95). Twenty of 29 (68.9%) heifers and 48 of 69 (69.5%) cows were confirmed pregnant and had their fetuses sexed by ultrasonography (Table 1). The mean insemination times for the early and late groups were 9.0 ± 0.1 and 22.9 ± 0.3 hours after onset of estrus, respectively. Based on ovulation occurring at 32 hours after the onset of estrus, the early and late inseminations would have been at least 20 and no more than 10 hours before ovulation, respectively. Timing of insemination had no effect on gender ratio (P = 0.89). The percentage of bulls and heifers was similar in both insemination groups.

Although Wehner et al. (1997) reported over 90% accuracy in preselecting the gender of calves by timing inseminations at approximately 20 or 10 hours before expected ovulation, we were unable to detect any effect of time of insemination on gender ratio in the present study. However, our results are in agreement with recent studies in dairy cattle. Jobst and Nebel (1998) analyzed data (representing 11 herds and 822 calvings) for differences in the male to female ratio of dairy calves born as the result of inseminations occurring at 0 to 8, 8 to 16, or 16 to 24 hours after the onset of estrus. All cows included in Jobst and Nebel's study had been continuously monitored with a HeatWatch system for actual onset of estrus, and calving dates were used to confirm breeding dates. The authors reported that overall, 53.5% of the calves born were bulls. There was no effect of parity, herd or time of insemination on the ratio of bull to heifer calves at calving. Another study in dairy cattle (Pursley et al., 1998) reported an increase in the percentage of females born as the result of inseminating at either 0 or 32 hours after onset of estrus, but no effect on the gender ratio of calves resulting from inseminations at 8, 16, and 24 hours after onset of estrus.

A recent study by Chandler et al. (1998) reported that within sires, the ratio of X- to Y-bearing spermatazoa from different ejaculates of semen can vary significantly and this varied ratio translates into altered sex ratio of offspring. Therefore, we recorded the sire and semen lot or freeze date for each insemination. Semen from 13 sires representing 17 lots was used to inseminate the cows and heifers. All semen lots were represented in both insemination groups. The number of pregnancies resulting from different lots of semen ranged from 1 to 12. Overall, no detectable differences (P = 0.49) were found in the gender ratios resulting from different sires or semen lots. Although there were differences noted in the percentage of bull and heifer calves resulting from insemination with different lots of semen, there were not enough calves produced from the various lots for meaningful comparison. Semen from the same sire but two different lots was used to inseminate all of the heifers in the present study. There was a tendency (P = 0.08) for more female pregnancies in heifers than cows (65 vs. 41.7%, respectively), regardless of time of insemination.

Length of estrus ranged from 0.5 to 20 hours, with a mean of 8.6 ± 3.7 hours. The number of mounts occurring during estrus ranged from four to 152, with a mean of 33.8 ± 27.8. Neither the length of estrus nor intensity (number of mounts) had an effect on conception rate or gender ratio (P ≥ 0.42). The time of insemination after the onset of estrus had no effect on pregnancy rate (P = 0.94). The results of our study indicate that acceptable pregnancy rates can be achieved in beef cattle over a range of insemination times if the time of actual onset of estrus is known. Pregnancy rates were almost identical (69%) for our early and late inseminations. Within the range noted in this study, length, and intensity (number of mounts) of estrus were related to pregnancy rate. Studies with dairy cattle also report no differences in pregnancy rate due to intensity or duration of estrus (Dransfield et al., 1998).

Implications

These results indicate that timing inseminations in beef cattle to occur at either 20 or 10 hours before ovulation does not alter the gender ratio. However, the results do indicate that acceptable pregnancy rates can be achieved over a range of insemination times if the time of actual onset of estrus is known.

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Table 1. Effect of time of insemination after the onset of estrus on pregnancy rate and gender ratio in cattle.

Item	Inseminated 8 to 10 hours after the onset of estrus	Inseminated 20 to 25 hours after the onset of estrus	Overall
No. inseminated	56	42	98
No. (%) pregnant	39 (69.6)	29 (69.0)	68 (69.4)
No. (%) bulls	21 (53.8)	15 (51.7)	36 (52.9)
No. (%) heifers	18 (46.2)	14 (48.3)	32 (47.1)

Effect of Estrous Parameters and Time of Insemination on Pregnancy Rate in Beef Cattle

Rick W. Rorie and Toby D. Lester[1]

Story in Brief

This study evaluated the effect of interval from synchronization treatment to onset of estrus, intensity (mounting activity) and length of estrus, and timing of insemination on pregnancy rate in beef cattle. An electronic estrous detection (HeatWatch®) system was used to continuously monitor onset of estrus. Cows detected in estrus (n = 295) were artificially inseminated between 7.5 and 26 hours after the onset of estrus. Pregnancy was confirmed by ultrasonography at 60 to 80 days of gestation. Overall, the single-service pregnancy rate was 71.5%. Within the range of insemination times in this study, pregnancy rate was not affected (P = .54). Pregnancy rate was not affected by the interval from synchronization treatment to estrus (P = .93). Length of estrus ranged from .5 to 23.3 hours and was not related (P = .82) to pregnancy rate. Comparison of data for open and pregnant cows indicated a possible trend for reduced fertility in animals with fewer mounts during estrus (P = .16). The results of this study indicate that subsequent pregnancy rate is unrelated to the interval from synchronization treatment to onset of estrus or length of estrus, but may be affected by estrus intensity. Knowing the actual time of onset of estrus allows for flexibility in time of insemination without compromising pregnancy rate.

Introduction

The general recommendation for artificial insemination of cattle is to observe cows at least twice daily and inseminate approximately 12 hours after detection of standing estrus. When cows are observed twice daily, there can be a difference of several hours between detected and actual onset of estrus. This difference might affect subsequent pregnancy rates. The HeatWatch® electronic estrus detection system allows for convenient, continuous monitoring for onset of estrus (based on mounting activity), so that the effect of actual time of insemination on pregnancy rate can be determined. This system also provides information on length of estrus and mounting activity that could be related to the success rate of artificial insemination. There are conflicting reports on the effect of time of insemination and other factors on conception rates in dairy cattle. In the present study, the HeatWatch system was used to evaluate the effect of interval from synchronization treatment to onset of estrus, length and intensity (mounting activity) of estrus, and timing of insemination on pregnancy rate in beef cattle.

Experimental Procedures

Angus cows and heifers ranging in body condition from 5 to 7 were used for this study. The cows were parity 1 to 8 and were 45 to 60 days postpartum. Heifers were synchronized by feeding 0.5 mg/head/day of melengestrol acetate (MGA) for 14 days. Seventeen to 18 days after MGA withdrawal, heifers were given an injection of prostaglandin F2 (Lutalyse®). The cows were synchronized by treatment with gonadotropin-releasing hormone (Cystroelin®) followed 7 days later by Lutalyse treatment. A HeatWatch electronic estrus detection system was used to continuously monitor the cows and heifers for mounting activity. The patches containing mount detection transmitters were placed on all animals at the time of Lutalyse injection. Onset of estrus was presumed to occur when three or more mounts with a duration of at least 1 second each were detected within a 4-hour period.

Animals detected in estrus (n = 295) were inseminated once, from 7.5 to 26 hours after the actual onset of estrus. An experienced technician performed all inseminations. Approximately two weeks after insemination, all animals were placed with clean-up bulls. Ultrasonography was used at 60 to 80 days of gestation to determine pregnancy status. Fetal crown-to-rump length (fetal size) was measured to determine if pregnancy resulted from artificial insemination or natural service. Cows or heifers confirmed pregnant by natural service were excluded from data analysis. Data for timing of insemination, interval from synchronization treatment to estrus, length of estrus and mount activity were categorized for analysis. The effect of these parameters on pregnancy rate was then evaluated by chi-square analysis. Analysis of variance was used to compare each parameter for open vs. pregnant cows.

[1]Both authors are associated with the Department of Animal Science, Fayetteville.

Results and Discussion

Overall, 211 of 295 cows and heifers were confirmed pregnant for a single-service conception rate of 71.5%. The interval from synchronization treatment to onset of estrus ranged from 4 to 147 hours. For analysis, data were categorized into 24-hour intervals (Table 1). The majority (74%) of the animals exhibited estrus 24 to 72 hours after synchronization treatment. The interval from synchronization treatment to onset of estrus had no effect on subsequent pregnancy rate (P = .93).

Pregnancy rate was compared for insemination times categorized in 4-hour intervals (Table 2). Pregnancy rates were similar among insemination times (P = .54). Our findings are supported by a study in dairy cattle, which reported pregnancy rates were similar for insemination occurring 0 to 24 hours after the onset of estrus. These results suggest that when the actual onset of estrus is known, timing of inseminations can be adjusted for convenience (within reason) without compromising pregnancy rate. However, it is likely that the optimum time of insemination could vary due to a number of factors such as semen quality and placement, and environment.

The period of standing estrus of individual cows and heifers ranged from less than 1 hour to almost 24 hours in this study. Pregnancy rate was similar (P = .82) regardless of length of estrus (Table 3). About 35% of the animals in this study had an estrus period of 8 hours or less. It is likely that some of these animals would have not been detected in estrus if they had be visually observed only twice daily. It would appear that the HeatWatch system's default parameters of three or more mounts of 1 second or more each within a 4-hour period is adequate for identifying most animals in estrus. However, some animals may only exhibit one or two mounts during their entire estrus period. It has been reported that animals that exhibit only one mount, but for several seconds duration, may become pregnant after insemination. However, the pregnancy rate is reduced in these animals.

Mounting activity ranged from four to over 147 mounts during estrus (Table 4). Numerically, pregnancy rate was higher for animals with 30 to 50 total mounts during estrus. However, statistical analysis reveals no difference in pregnancy rate due to mounting activity (P = .23). Comparison of all pregnant vs. open cows (Table 5), reveals a trend (P = .16) for cows with fewer mounts during estrus to have reduced fertility. Some studies with dairy cattle indicate fertility is reduced in cows with few mounts during estrus while others report no effect of mounting activity on pregnancy rate. The interval from synchronization treatment to estrus, length of estrus and interval from onset of estrus to insemination were similar for open and pregnant cows (P ≥ .32).

Implications

Timing of artificial insemination can be adjusted within reason without compromising pregnancy rate if the actual onset of estrus is known. Length of estrus, and time required for animals to exhibit estrus after synchronization treatment do not appear to be related to subsequent pregnancy rate. Further study is needed to assess the effect of estrus intensity on pregnancy rate.

Table 1. Effect of interval from PGF2 Alpha Treatment to estrus on subsequent pregnancy rate.

Interval, PGF2 alpha to estrus (h)	No. of animals	Category Mean ± SE	Percent pregnant
≤ 24	15	14.1 ± 1.96	73.3 ± .12
> 24 to 48	84	38.3 ± .83	67.9 ± .05
> 48 to 72	134	58.9 ± .65	72.4 ± .04
> 72 to 96	39	83.9 ± 1.21	74.4 ± .07
> 96	23	117.5 ± 1.58	73.9 ± .09

Table 2. Effect of interval from onset of estrus to insemination on conception rate.

Onset of estrus to A.I. (h)	No. of animals	Category Mean ± SE	Percent pregnant
≤ 8	10	7.0 ± .42	80.0 ± .14
> 8 to 12	69	9.8 ± .16	68.1 ± .05
> 12 to 16	69	14.3 ± .16	68.1 ± .05
> 16 to 20	67	17.8 ± .16	77.6 ± .05
>20 to 24	66	22.3 ± .16	68.2 ± .06
> 24	14	25.8 ± .36	85.7 ± .12

Table 3. Effect of length of estrus on subsequent pregnancy rate.

Length of estrus (h)	No. of animals	Category Mean ± SE	Percent pregnant
≤ 4	19	2.7 ± .25	68.4 ± .10
> 4 to 8	86	6.6 ± .12	68.6 ± .05
> 8 to 12	114	10.1 ± .10	71.9 ± .06
> 8 to 16	55	13.9 ± .15	72.7 ± .06
> 16 to 20	15	18.1 ± .28	86.7 ± .12
> 20 to 24	6	21.8 ± .45	66.7 ± .19

Table 4. Effect of mounting activity on subsequent pregnancy rate.

Number of mounts	No. of animals	Category Mean ± SE	Percent pregnant
≤ 10	66	7.0 ± 1.20	65.2 ± .06
11 to 20	70	15.3 ± 1.16	65.7 ± .05
21 to 30	53	24.9 ± 1.33	71.7 ± .06
31 to 40	31	35.5 ± 1.75	87.1 ± .08
41 to 50	28	44.8 ± 1.84	82.1 ± .09
51 to 60	15	56.5 ± 2.51	66.7 ± .12
> 60	32	92.0 ± 1.72	75.0 ± .08

Table 5. Comparison of estrous parameters of open and pregnant beef cows.

Item	Pregnancy status		P-value
	Open	Pregnant	
No. of animals	84	211	
Interval to estrus (h)	58.0 ± 2.75	58.0 ± 1.73	.778
No. of mounts	27.0 ± 2.97	31.9 ± 1.87	.164
Length of estrus	9.6 ± .45	10.2 ± .28	.318
Interval to A.I. (h)	15.9 ± .59	16.2 ± .37	.629

Evaluation of a Two-Part Melengestrol Acetate Estrus Synchronization Regime

Shelley Wright, David Kreider, Rick Rorie, Natalie Huber, and Gary Murphy[1]

Story in Brief

An experiment was conducted using postpartum beef cows to evaluate the use of a two-part Melengestrol Acetate (MGA) treatment to synchronize estrus. Cows were randomly assigned to treatment groups by days postpartum and lactation status. Initial body weights were similar (P = .26) between the Control (107 ± 29 lb; mean ± standard error) and Treatment group (1029 ± 30 lb). Initial body condition scores (BCS) for the Control and Treatment groups were also similar (4.6 ± .1 vs. 4.8 ± .1; P = .19). Both the Control and Treatment groups received 5 lb of supplement per head per day containing .5 mg MGA for 14 consecutive days followed by a 17-day withdrawal during which cows received 5 lb per head per day of supplement without MGA. On day 17 after the MGA withdrawal, cows in the Control group received a 25-mg intramuscular injection of prostaglandin F_2 (Lutalyse®), while cows in the Treatment group were fed supplement containing MGA at .5 mg/head/day for an additional 5 days. In the 10 days following the Lutalyse injection (Control group) or the second MGA withdrawal (Treatment group), estrus was monitored by a Heat Watch® (DDX, Denver) electronic estrus detection system. Cows that were detected in estrus in the morning were artificially inseminated that evening and cows that were in estrus in the evening were inseminated the following morning. During the 10-day period in which estrus was monitored, 79% (30/38) of the control group were detected in estrus compared to 86% (31/36) animals in the Treatment group. Conception rates determined by ultrasound at approximately 30 days after artificial insemination were 48.1% and 46.6% for the Control and Treatment groups respectively and were not different (P = .91). This study suggests that a two-part MGA feeding regime could be used successfully to synchronize estrus in postpartum beef cows.

Introduction

The effectiveness of an estrus synchronization system is measured by its ability to elicit a fertile, tightly synchronized estrus in a majority of treated females (Odde, 1990). Ideally, a system should be cost-effective, require minimum labor, entail limited animal handling, and be user-friendly to a producer (Odde, 1990; Patterson et al., 1992). Orally administered Melengestrol Acetate (MGA) has been proven to effectively suppress estrus and achieve estrus synchronization. However, estrus with low fertility is normally a consequence of estrus synchronized with MGA. Research has shown that the low fertility is the result of the development of a persistent follicle on the ovary of some animals that has an extended life span during the MGA treatment. The persistent follicle is caused by the frequent pulsatile release of LH due to incomplete suppression of LH release by the levels of MGA fed (McDowell et al., 1998). Melengestrol Acetate withdrawal results in ovulation of the persistent (aged) follicle which usually has low fertility. Further research has shown that treatment with MGA initiated when a functional corpus luteum is present usually does not result in development of a persistent follicle with low fertility (Yelich et al., 1997). The objective of this study was to determine if a two-part MGA treatment would effectively synchronize estrus and give acceptable conception rates in suckled postpartum beef cows.

Materials and Methods

Primiparous (first calf) and multiparous cows from the crossbred (predominantly Angus) beef herd at the University of Arkansas research unit at Savoy were used to compare two estrus synchronization regimes. At the start of the experiment (day 0), all 74 cows were weighed and assigned a body condition score (BCS) of 1 to 9 (1 = extremely emaciated, 9 = extremely obese). Animals were then randomly assigned to one of two treatment groups. Both the Control and Treatment groups received 5 lb of supplement (Table 1) per head per day containing .5 mg MGA for 14 consecutive days (day 0 to day 14) followed by a 17-day withdrawal (day 15 to day 31) during which cows received 5 lb per head per day of supplement without MGA. On day 31, cows in the Control group received a 25-mg intramuscular injection of prostaglandin F_2 (Lutalyse®, Pharmacia-Upjohn, Kalamazoo) and cows in the Treatment group received supplement con-

[1]All authors are associated with the Department of Animal Science, Fayetteville.

taining MGA at .5 mg/head/day for an additional 5 days. All cows on all treatments were bunk fed and were kept on the same pastures or hay (mixed fescue *(Festuca arundinacea)* and clover *(Trifolium repens, Trifolium dubium)* during the first 31 days of the experiment (14 days on MGA + 17-day withdrawal). The application of treatments is illustrated in Fig. 1. Cows had free access to water and mineral supplement during the entire experiment. In the 10 days following the Lutalyse injection (Control group; day 31 to day 41) or the second MGA withdrawal (Treatment group; day 36 to day 46) estrus was monitored by a Heat Watch (DDX, Denver) electronic estrus detection system. Cows displaying estrus in the morning were artificially inseminated that evening and cows displaying estrus in the evening were inseminated the following morning. Pregnancy rates were determined at approximately 30 days from the last day of artificial insemination in both groups by ultrasonography.

Differences in the percentage of animals that exhibited estrus after treatment and pregnancy rate to artificial insemination were compared using Chi- Square analysis in JMP of SAS (1989). Time to estrus after Lutalyse injection or MGA withdrawal was compared by ANOVA of JMP of SAS (1989). There was no significant difference in treatment effects due to maternal status (primiparous vs. multiparous); therefore, data for primiparous and multiparous cows were combined for the analysis of results.

Results

Body weight and BCS data for the two treatments are summarized in Table 2. Average body weight and BCS scores at the start of the experiment were not significantly different between the two treatments. Percent of cows showing estrus and time to estrus after the first MGA withdrawal (day 15 to day 31) are shown in Table 3. A total of 77.7% (57/74) animals were detected in estrus at an average time of 110.7 ± 4.2 hours. There was no difference in the response of Control and Treatment groups in time to estrus or percent in estrus after the first MGA withdrawal.

Data for estrus response and pregnancy rates to AI after the Lutalyse injection and the second MGA withdrawal are presented in Table 4. Seventy-nine percent (30/38) of the Control animals were detected in estrus compared to 86% (31/36) of the Treatment group. Hours to estrus were numerically lower for the Control group (93.5 ± 12.5) compared to the Treatment group (116.6 ± 12.8) but were not significantly different. Pregnancy rates at 30 days after the last artificial insemination were not different between the treatments (48.1% vs. 46.6% for Control and Treatment, respectively) .

Discussion

The two-part MGA estrus synchronization regime evaluated in this experiment resulted in a numerically higher percentage of cows in estrus than the Control group although the comparison was not statistically different. Pregnancy to artificial insemination was comparable for both groups. The data presented suggests that a two-part MGA regime might be a successful and easily adapted method of estrus synchronization in beef cows. There was no evidence in this study to suggest the second short-term exposure to MGA used in this experiment had detrimental effects on pregnancy rate when compared to the commonly used method of synchronization used in the Control group.

Implications

Results of this study indicate that a two-part MGA estrus synchronization may offer an effective way to synchronize animals, with the advantage of a more cost effective program that does not require the handling of cattle for one or more injections. Pregnancy rates were similar to the more commonly used protocol of MGA followed by a Lutalyse injection. Further research is needed to substantiate these results and to better evaluate pregnancy rates to artificial insemination following synchronization by this method.

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Table 1. Composition of cow supplement.

Ingredient	Pounds
Corn	1,750
Soybean meal	180
Molasses	46
Limestone	20
Vitamins A, B, & E premix	4

Table 2. Body weight and BCS (Mean ± SE) by treatment group.

Treatment group	Number	Body weight (lb)	BCS[1]
Control	38	1,076 ± 29	4.6 ± .1
Treatment	36	1,029 ± 30	4.8 ± 1

[1]Scores 1 to 9; 1 = extremely emaciated, 9 = extremely obese.

Table 3. Estrus response after first MGA withdrawal and hours to estrus.

Treatment group	% in estrus	Number/Total	Avg. hours to estrus
Control	76.3	29/38	115.0 ± 6.6
Treatment	77.8	28/36	106.3 ± 6.7
Total	77.7	57/74	110.7 ± 4.2

Table 4. Estrus response and pregnancy rates after Lutalyse injection or second MGA withdrawal.

Treatment group	Percent in estrus	Number/total	Avg. hours to estrus	Percen Pregnant at 30 days
Control	79	30/38	93.5 ± 12.5	48.1
Treatment	86	31/36	116.6 ± 12.8	46.6

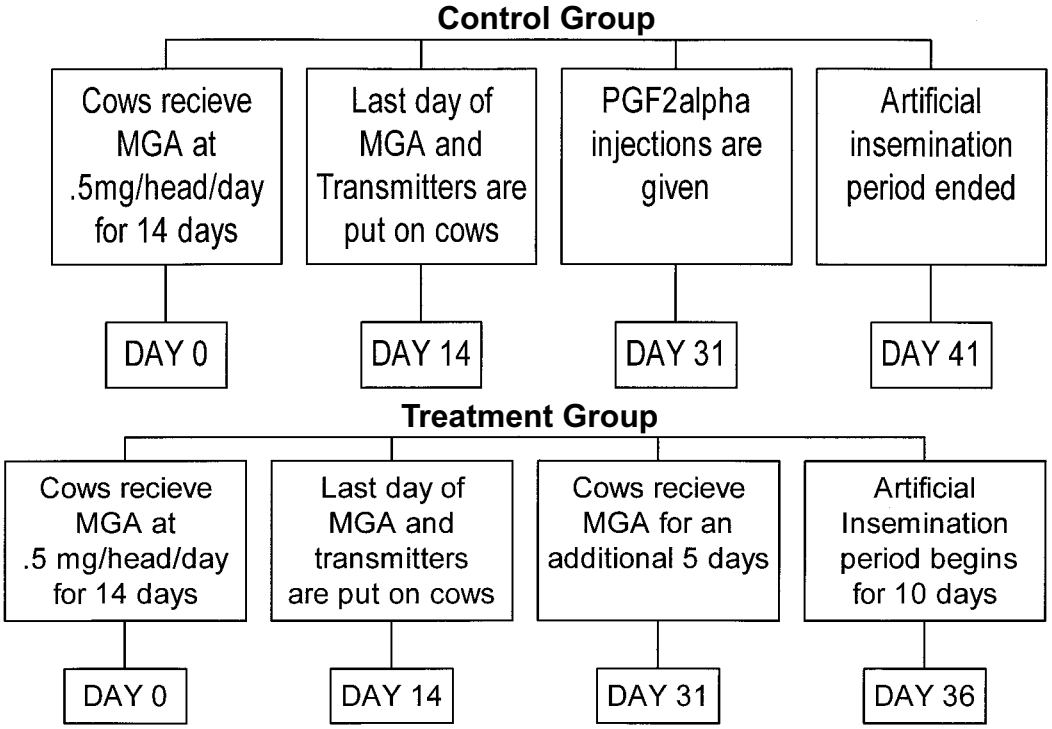

Fig. 1. Allocation of treatments.

Persistent Efficacies of Doramectin and Ivermectin in Arkansas Stocker Calves

T.A. Yazwinski, Chris Tucker, Zelpha Johnson, Homer Featherston, and Sharon Copeland[1]

Story in Brief

The persistent efficacies of doramectin injectable solution (DECTOMAX®, Pfizer) and ivermectin injectable solution (IVOMEC®, Merial) were compared for use in stocker calves. Parasite-free calves were treated with the parasiticides, subsequently challenged with infective nematode larvae and then necropsied for parasite counts. Significantly ($P < .05$) fewer total nematodes were recovered at necropsy from doramectin-treated calves than from ivermectin-treated calves when parasite challenge was given at 14 or 21 days after treatment. Doramectin displayed a greater magnitude and duration of efficacy than did ivermectin against the establishment of infections by *Ostertagia*, *Cooperia*, *Oesophagostomum,* and *Trichostrongylus* genera nematodes.

Introduction

Internal parasite control for cattle has evolved in stages. In the 1960s, products that were ineffective, toxic, or both were replaced with thiabendazole, levamisole and morantel. In the 1970s, a family of compounds related to thiabendazole were isolated and investigated. Those which became cleared for use in USA cattle were fenbendazole, oxfendazole, and albendazole. In the early 1980s, parasite control entered its current era with the availability of macrolides; molecules that are produced by the bacterium *Streptomyces* and are active not only against nematode parasites, but insect and arachnid parasites as well. The first available macrolide was ivermectin, followed in the USA by doramectin, eprinomectin and moxidectin. These "endectocides" (products which kill both helminths and external parasites) are very similar in chemical structure, and therefore share many attributes (Shoop et al. 1995; McKeller and Benchaoui, 1996). One characteristic of macrolide preparations is persistence *i.e.* the period of time after treatment when residual levels of endectocide provide protection against new infections. It is this characteristic of persistence which has been the focus of considerable research wherein "safe" post-treatment periods are documented for each product and comparisons are made between products. The data reported here are from a study where the protective period of injectable ivermectin is compared with the protective period of injectable doramectin.

Experimental Procedures

Stocker calves (N = 55) were treated with fenbendazole at the dose rate of 10 mg/kg BW and placed on clean concrete for the remainder of the study to preclude exposure to any extraneous nematode challenge. Seven days later (14 days before the trial began), the fenbendazole treatments were repeated; this to insure parasite-free status of all calves. On trial day 0, 49 of the calves were selected for the study based on health and homogeneity of weight, weighed (range was 240 to 355 lb), blocked by weight into seven groups of seven, and randomly assigned treatment group designation (1 through 7) within each block. Animals were then penned by treatment group. Treatment groups were treatment with doramectin (DECTOMAX®, Pfizer) or ivermectin (IVOMEC®, Merial) on day 0, day 7, or day 14 (both given at the rate of 200 mcg/kg body weight by subcutaneous injection). The seventh group of calves served as the control. On trial day 28, each calf was orally administered an infection dose consisting of approximately 15,800 *Cooperia*, 7,100 *Ostertagia*, 5,100 *Trichostrongylus*, 2,300 *Oesophagostomum* and 1,800 *Haemonchus* L3 larvae of recent field isolation.

On trial days 49, 50, and 51 all animals were fecal sampled for parasite egg counts, euthanized, and necropsied for parasite recovery and quantification. All parasitological techniques used have been detailed elsewhere (Yazwinski et al., 1994) and are consistent with the currently governing guidelines (Wood et al., 1995).

The data were analyzed with general linear models (SAS, 1988). One-way analysis of variance was used to assess treatment effect on EPG (parasite eggs per gram of feces) and parasite counts. When control animal counts of zero were observed for a particular parasite, they, and an equal number of corresponding zero counts in each of the other groups were excluded from statistical analysis. Parasite and EPG counts were transformed to the natural log (count + 1) before analysis. All data were back-transformed to geometric means for presentation and persistent efficacy calculations by standard formula.

[1]All authors are associated with the Department of Animal Science, Fayetteville

Results

Geometric means of EPG counts as well as incidence of patent infections, both as determined at necropsy, are presented in Table 1. Animals treated with either avermectin at 28 d prior to larval challenge displayed EPG counts similar to control calf levels. Likewise, calves receiving ivermectin at 21 days prior to challenge displayed EPG counts similar to those of control calves ($P < .05$). Contrastingly, doramectin treatment at 21 days before challenge resulted in EPG levels significantly lower than control counts ($P < .05$). For calves receiving treatments at 14 days prior to challenge, necropsy EPG levels were significantly lower for doramectin than for ivermectin treated calves, with no patent infections evident in the doramectin group as opposed to a 57% incidence of patency (4/7) for ivermectin treated calves.

Geometric means by treatment group of calculated total nematode counts as seen at necropsy are presented in Table 2.Treatment induced percent reductions based on these means are presented in Table 3. Of the nematodes provided at challenge, *H. placei*, *O. lyrata*, *C. spatulata,* and *T. colubriformis* failed to establish in control animals at an incidence that permitted definitive treatment group comparisons, and are therefore not included in this report. When given at 28 days pre-challenge, doramectin significantly reduced ($P < .05$) the establishment of subsequent populations of all *Ostertagia* forms as well as fourth stage larvae of *Cooperia* spp and *O. radiatum*. Given at the same pre-challenge interval, ivermectin significantly reduced only subsequent populations of fourth stage larvae of *Ostertagia* and *Cooperia* spp. *T. axei* proved most refractory to persistent anthelmintic activity with 0.0% reductions in burden establishment for both avermectins as administered at 28 days pre-challenge.

When given at 21 days prior to nematode challenge, the differences in persistent activity by the two avermectins were most demonstrable. Of the 13 nematode populations (genus/species/sex/stage of development) quantified at necropsy and of sufficient incidence to provide meaningful statistical inference, eight populations were reduced to a significantly greater extent when prior treatment was with doramectin than with ivermectin ($P < .05$). Of the remaining five nematode populations, doramectin displayed greater percent reductions than did ivermectin although corresponding group means were not significantly different.

When given 14 days prior to nematode administration, doramectin and ivermectin reduced subsequent establishment of parasite populations by 98.8 to 100.0 and 76.4 to 99.6%, respectively. Six of the 13 parasite populations were reduced significantly more by doramectin than by ivermectin treatment ($P < .05$).

Discussion

In the current study, persistent efficacies of doramectin and ivermectin were assessed for 14-, 21-, and 28-day intervals between treatment and subsequent nematode challenge. Thirteen nematode populations (genus/species/stage/sex) were quantified at necropsy and analyzed. In no instance was ivermectin significantly more effective than doramectin in preventing nematode establishment. Conversely, when given at 14, 21, and 28 days prior to challenge, doramectin reduced subsequent nematode populations significantly more than ivermectin for six, eight, and two of the l3 quantified nematode forms, respectively ($P < .05$).

According to the World Association for the Advancement of Veterinary Parasitology, an anthelmintic is considered effective when a nematode reduction percentage of ≥ 90% is realized (Wood et al., 1995). Effectiveness for ivermectin was shown to persist after treatment for at least 14 days, but less than 21 days for *Cooperia* and *Ostertagia*. For doramectin, effectiveness against *Cooperia* was seen to last at least 21 days but less than 28 days after treatment. For the prophylaxis of *Ostertagia* infections, an end point of effective persistent efficacy was not established for doramectin in the current study, with ≥ 94.8% reduction in *Ostertagia* infections, which resulted from larvae administered at 28 days after treatment. The more prolonged persistent efficacy conferred by doramectin as opposed to ivermectin should prove significant to the well-being of Arkansas stocker calves; animals which acquire *Ostertagia* and *Cooperia* from contaminated pasture at rates that exceed 2,000 parasites per calf per day (Yazwinski et al., 1995).

As used in the current study (commercial injectable formulations), doramectin far exceeded ivermectin in effectively prohibiting post-treatment nematode establishment. The cause of this enhanced persistence has not to date been totally defined. In studies that document the pharmacokinetics of doramectin and ivermectin when administered by subcutaneous injection (Lanusse et al., 1997; Toutain et al., 1997), doramectin was shown to have greater post-treatment blood levels than ivermectin; an element of bioavailability which might account for the greater anthelmintic persistence of doramectin as compared to ivermectin. However, levels of circulating (blood plasma) avermectin may only in part be responsible for persistent efficacy. Additional factors that may influence persistence include animal sex and fat content, intestinal tract rate of passage and chemistry, stage of parasite development, tendencies for some parasites to sequester at sites of low anthelmintic titer and anthelmintic formulation. This last factor is illustrated in a study showing that persistence of ivermectin is much greater against worms when delivered by injection as opposed to pour-on (Yazwinski et al., 1994).

A number of benefits have been ascribed to the persistence of anthelmintics (Brunsdon et al., 1989). These benefits include protection against re-infection for an extended posttreatment period, a decrease in the number of antiparasitic treatments cattle must receive in order to maintain profitable production and lastly, a means by which pasture contamination may be lessened as a result of grazing by recently-treated animals. Unfortunately, possible negative impacts of persistence might also exist. Respective data and/or predictions presented to date include; a lessening of host protective immunity resulting in decreased animal performance

during subsequent grazing periods (Vercruysse et al., 1995), a selection for resistant parasites due to challenge during persistent yet only partially effective drug presence (McKenna, 1987) and long-term introduction of "ecotoxic" compounds into the environment (Herd et al., 1996). All the above warrant monitoring, for their documentation in regard to cattle production might well impact on the continued use and benefits of persistent compounds.

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Table 1 - Parasite, fecal egg count data at necropsy.

Compound[1]	Control	DRM	IVM	DRM	IVM	DRM	IVM
DTA[2]	NA	28	28	21	21	14	14
EPG, geometric Mean	23[ab]	22[ab]	38[a]	5[c]	16[abc]	0[d]	4[c]
Egg count positive at necropsy[3]	7/7	7/7	7/7	5/7	5/6[4]	0/7	4/7

[1] Compounds DRM (doramectin) and IVM (ivermectin).
[2] DTA = days elapsed from treatment to larval challenge.
[3] No. positive/Total No. in treatment group.
[4] One animal died prior to scheduled necropsy due to circumstances unrelated to experimental treatment.
[a, b, c, d] Means on the same line with unlike superscripts are different ($P < .05$).

Table 2 - Treatment group, geometric means of calculated total nematode counts for calves as determined at necropsy.

		Days elapsed between treatment and subsequent nematode challenge					
		28		21		14	
Nematode	Non-medicated	Doramectin	Ivermectin	Doramectin	Ivermectin	Doramectin	Ivermectin
Ostertagia							
- *ostertagi* (female)	1054.5[a]	30.2[b]	377.1[a]	7.0[b]	122.8[a]	0.0[c]	17.5[b]
- spp (male)	1278.6[a]	52.7[b]	504.9[a]	15.8[b]	150.5[ab]	0.3[b]	10.0[b]
- EL4	41.2[a]	0.6[b]	1.7[b]	0.1[c]	2.9[b]	0.1[b]	0.1[b]
- DL4	125.1[a]	6.5[b]	14.9[b]	4.9[b]	11.1[b]	0.3[b]	3.8[b]
Trichostrongylus *axei*							
- adult	266.8[a]	401.9[a]	307.9[a]	41.1[b]	403.7[a]	0.5[c]	24.0[b]
- L4	29.6[a]	62.9[a]	33.4[a]	5.7[b]	37.7[a]	0.3[b]	7.0[a]
Cooperia							
- spp (male)	2168.5[a]	1421.6[a]	1531.8[a]	139.2[b]	906.3[a]	0.3[c]	72.7[b]
- *oncophora* (female)	901.0[a]	930.7[a]	898.1[a]	58.2[b]	507.2[a]	0.2[c]	20.7[b]
- *punctata* (female)	417.7[a]	67.1[a]	262.4[a]	5.8[b]	97.8[a]	0.0[c]	11.2[b]
- *surnabada* (female)	83.1[a]	111.5[a]	67.3[a]	9.2[b]	30.4[ab]	0.1[b]	1.7[b]
- spp L4	60.8[a]	6.9[b]	13.1[b]	2.7[b]	18.0[a]	0.0[b]	1.9[b]
Oesophagostomum *radiatum*							
- adult	79.9[a]	2.3[a]	23.3[a]	3.1[a]	15.2[a]	0.1[a]	4.3[a]
- L4	183.1[a]	11.3[b]	82.2[ab]	10.3[b]	30.0[ab]	0.0[b]	6.7[b]

[a, b, c] Means on the same line with unlike superscripts are different ($P < .05$).

Table 3 - Reductions (%) in mean nematode counts in medicated groups of calves as compared to counts in the non-medicated group.

Nematode	Days elapsed between treatment and subsequent nematode challenge					
	28		21		14	
	Doramectin	Ivermectin	Doramectin	Ivermectin	Doramectin	Ivermectin
Ostertagia						
- *ostertagi* (female)	97.1	64.2	99.3	88.3	100.00	98.3
- spp (male)	95.8	60.5	98.7	88.2	99.9	99.2
- EL4	98.5	95.9	99.7	93.0	99.7	99.6
- DL4	94.8	88.1	96.1	91.1	99.7	96.9
Trichostrongylus *axei*						
- adult	0.0	0.0	84.6	0.0	99.8	90.9
- L4	0.0	0.0	80.7	0.0	98.8	76.4
Cooperia						
- spp (male)	34.4	29.3	93.5	58.2	99.9	96.6
- *oncophora* (female)	0.0	0.3	93.5	43.7	99.9	97.7
- *punctata* (female)	83.9	37.1	98.6	97.8	100.0	97.3
- *surnabada* (female)	0.0	19.0	88.9	63.4	99.8	97.9
- spp L4	88.6	78.4	95.5	70.4	100.0	96.8
Oesophagostomum *radiatum*						
- adult	97.1	70.8	96.0	80.9	99.8	94.6
- L4	93.8	55.0	94.3	30.0	100.0	96.3

Factors Influencing Sale Price Among Bulls Enrolled in an On-Farm Bull Testing Program

Stan McPeake and Clay Cochran[1]

Story in Brief

Data was collected on 125 Charolais bulls over a two-year period (1998 and 1999) to determine the relationship of various factors on selling price. Factors evaluated were: age of bull, horn classification, sale year, actual birth weight, adjusted weaning weight, scrotal circumference, average daily gain on test, EPDs for birth weight, weaning weight, yearling weight, milk, and total maternal EPD. A regression analysis was conducted to determine the relative importance of the factors in predicting sale price. The top seven factors affecting sale price listed in order of importance are: sale year, adjusted weaning weight, scrotal circumference, horn classification, average daily gain on test, bull age and total maternal EPD. These factors accounted for 67% of the variation in sale price.

Introduction

To increase herd productivity and hopefully profitability, economically important traits (fertility, growth, maternal traits, and carcass merit) should be emphasized in selection programs. Since sire selection is responsible for most of the genetic improvement within a herd, sound choices of potential herd sires are of utmost importance. One way of decreasing some of the variation among bulls is by performance testing on the farm. On-farm bull testing provides both purebred and commercial producers an opportunity to compare and evaluate bulls managed under common nutritional and environmental conditions. The objective of this study was to determine the influence of bull characteristics, performance measurements and year of sale on the selling price of on-farm performance tested bulls.

Experimental Procedures

Performance data were collected during 1998 and 1999 on 125 Charolais bulls completing a 112-day on-farm bull test. The bulls were approximately 7 to 8 months of age at the beginning of the test period. They were allowed a 21-day warm up period prior to starting the official gain test. Initial weights were taken on all bulls. Upon completion of the 112-day test, approximately when bulls were one year of age, yearling hip heights and scrotal circumference measurements were taken.

Bull characteristics and performance data were correlated with sale prices of 125 bulls that sold in 1998 and 1999. Variables included were age of bull in years (1, 1.5, and 2), horn classification (polled = 1, dehorned = 2, or scur = 3), year of sale (1998 and 1999), actual birth weight, adjusted weaning weight, EPDs for birth weight, weaning weight, yearling weight, milk, total maternal, scrotal circumference, and average daily gain along with sale price.

Sale catalogs were available to buyers prior to each sale. The catalogs included identification of each bull, a two-generation pedigree and birth date. Up-to-date EPDs were provided on a supplemental sheet. Breed average EPDs, however, were not provided in the catalog. Performance data reported in each catalog were: actual birth weight, adjusted weaning weight, average daily gain and scrotal circumference. Contributions of each factor (bull characteristics, performance data and year of sale) were independently evaluated using a multiple regression procedure to obtain partial regressions of sale price on each factor.

Results and Discussion

Phenotypic correlation coefficients between selling price, bull characteristics and performance traits measured during the study are presented in Table 1. Year of sale, horn classification, adjusted weaning weight, total maternal EPD, weaning weight EPD, scrotal circumference and average daily gain were all significantly ($P < .05$) correlated with selling price. Adjusted weaning weight, weaning weight EPD, total maternal EPD, scrotal circumference and average daily gain were all positively correlated with selling price.

The negative correlation between selling price and horn classification indicates that producers paid more for polled bulls as compared to horned bulls that were dehorned. Producers paid more for polled bulls because calves from these bulls would be mostly polled depending on whether the bulls were homozygous polled or heterozygous polled. Positive correlations were noticed with factors related to weaning

[1]Both authors associated with the Animal Science Section, Cooperative Extension Service, Little Rock

weight, such as adjusted weaning weight, weaning weight EPD and total maternal EPD. Most commercial producers are interested in selling weaning weight, so this may be one reason that commercial buyers showed such an interest in these performance traits. Average daily gain and scrotal circumference also had positive correlations with selling price.

Table 2 presents the impact that a per unit change in each trait had on selling price. Most of the factors examined made significant contributions to selling price with the exception of birth weight EPD, weaning weight EPD, yearling weight EPD, milk EPD and actual birth weight. A 10 lb differential in adjusted weaning weight was associated with a $20.60 difference in selling price. There was a $209.57 differential between polled versus horned bulls. An average daily gain differential of 1 lb was associated with a $135.06 difference in selling price. A six-month difference in age of bull was associated with a differential of $174.65 in selling price. A one-year difference in age of bull was associated with a differential of $349.30 in selling price.

The ranking of these traits by partial R^2 indicates that producers are concerned about traits that are related to weaning weight, fertility, and marketability.

Implications

It is important to note that both sale order and the physical appearance of the bulls on sale day may have had a profound effect on these results. Bulls have phenotypic characteristics that may lead to an increase or decrease in price on sale day. The extent to which visual appraisal is used to determine price is unknown but may be quite large. In addition, certain pedigrees and bloodlines may have a significant impact on the selling price of bulls. The reason some bulls sell at a higher price than others is sometimes unexplainable, but this data indicates that buyers considered traits measured on the bull directly. Some consideration was given to EPD information; however, bull buyers still direct attention to the physical characteristics of the bull. A bull buyer should first evaluate the performance data that is available on a bull and then decide if he has desirable physical attributes.

Acknowledgment

The Cooperative Extension Service, University of Arkansas would like to especially thank Tim Leslie and Eddie Loggains of Tim Leslie Charolais Ranch for their assistance in collecting data used for this study.

Table 1. Significant correlation coefficients between sales price, bull characteristics, performance traits and year of sale.

	Price
Year of sale	-.49**
Adjusted weaning weight	.27**
Scrotal circumference	.39**
Horn classification	-.28**
Average daily gain	.39**
Total maternal EPD	.23**
Weaning weight EPD	.21*

* Significance level: (P < .05)
** Significance level: (P < .01)

Table 2. Partial regressions of sale price on bull characteristics, performance traits, and year of sale.

Trait	Regression coefficients	Partial R^2	Model R^2
Year of sale	-501.51**	.21	.21
Adjusted weaning wt	2.06**	.18	.40
Scrotal circumference	18.35**	.14	.54
Horn classification	- 209.57**	.05	.59
Average daily gain	135.06**	.03	.62
Age of bull	349.30*	.02	.65
Total maternal EPD	9.16**	.02	.67

*Significance level: (P < .05)
**Significance level: (P < .01)

Arkansas Steer Feedout Program 1997-1998

Tom Troxel, George Davis, Shane Gadberry, Stan McPeake, and William Wallace[1]

Story in Brief

The objective of the Arkansas Steer Feedout Program is to provide cow-calf producers information about the postweaning performance and carcass characteristics of their calves. Steers that were composed of more than 50% English, less than 50% exotic, and less than 25% Brahman breeding had a higher percentage of grade Choice than steers that did not satisfy the breed type description (54% vs. 25%). Feed cost of gain, quality grade, medicine cost, dressing percentage and fat thickness were significant factors that affected net return. With the information gained from this program, cow-calf producers can better evaluate their cattle breeding program.

Introduction

The Steer Feedout Program allows producers to learn more about the characteristics of their calf crop and the factors that influence value beyond the weaned-calf phase. The Steer Feedout Program is not a contest to compare breeds or breeders, and it is not a retained ownership promotion program. It creates an opportunity for producers to determine how their calf crop fits the needs of the beef industry and provides information needed to determine if changes in genetics and/or management factors are warranted.

Experimental Procedures

During the week of October 10, 1997, entries from 103 ranches (1,019 head) were placed on feed at Randall County Feedyard at Amarillo. Steers came from Texas, New Mexico, Oklahoma, Arkansas, and Florida. Arkansas had 239 (24%) of the 1,019 steers. The Steer Feedout Program was held in cooperation with the Texas A&M Ranch-to-Rail program to compare Arkansas steers with steers from other states. Upon arrival, steers were eartagged, weighed, and processed (implanted and vaccinated for clostridial and respiratory diseases). Each steer was assigned a per hundredweight value based on current local market conditions by Federal-State Livestock Market News Service personnel. This served as a basis for calculating theoretical break-evens and the financial outcome of the program. The steers were sorted into eleven feeding groups based upon weight, frame, condition, and biological type. Management factors such as processing, medical treatments, and diets were the same as the other cattle in the feedyard. Individual animals were selected for slaughter by the feedyard manager when they reached the weight and condition regarded as acceptable for the industry and market conditions. The cattle were sold on a carcass weight basis with premiums and discounts for various quality grades, yield grades and carcass weights. Feed, processing, and medicine costs were financed by the feedyard. All expenses were deducted from the carcass income and proceeds were sent to the owner.

Descriptive statistics were computed to describe general program results. Breed type of each steer enrolled in the program was used to group calves according to whether or not they fit the following criteria: $\geq$ 50 % English, $\leq$ 50% exotic, and $\leq$ 25% Brahman. The main effects of year and group and their interaction on the dependent variables yield grade, ribeye area, ribeye area/hot carcass cwt., ADG, dressing percent, feed cost per pound of gain, and net return were determined using the PROC GLM procedure of SAS (1990). Fat thickness was used as a covariant in the model.

Steers were also grouped according to whether or not they fit an industry standard for carcass merit (at least Choice, yield grade 3.5 or better, with a hot carcass weight between 550 and 950 pounds). Data was analyzed in the same manner as the breeding group analysis. Least-squares means (SAS, 1990) were computed and reported.

Factors affecting net return of all steers, top 25% (based on net return), and bottom 25% were determined by year using the stepwise method of PROC REG (SAS, 1990). Independent variables included in weight, percentage Brahman, percentage English, percentage exotic breeding, ADG, yield grade, quality grade, feed cost per pound of gain, hot carcass weight, days on feed, medicine cost, ribeye area, ribeye area/hot carcass cwt., and dressing percentage.

Results and Discussion

On the average, the 1997-98 Arkansas steers had: (1) higher feeder calf value, (2) higher medicine costs, (3) higher death loss, and (4) lower gross income value than the 1996-

[1]All authors are associated with the Animal Science Section, Cooperative Extension Service, Little Rock

97 Arkansas steers (Table 1). Although the average net return for the 1997-98 steers was -$68.74 with a range from $138.74 to -$215, 35% of the 1997-98 steers had a positive net return.

The average off-the-truck weight for the Arkansas steers was 643 lb (420 to 850). The average daily gain, average days on feed, feed cost per pound of gain, and total cost per pound of gain were 2.67 lb (1.36 to 4.19), 191 days (154 to 215), $0.58 ($0.36 to $1.16), and $0.66 ($0.42 to $1.30), respectively.

The average carcass weight, ribeye area, dressing percentage, yield grade, and fat thickness were 741 lb (529 to 939), 13.6 in^2 (9.1 to 19.0), 65% (57.6% to 74.6%), 2.27 (1.00 to 4.10), and .36 in (.08 to .84), respectively. Twenty-seven percent of the carcasses graded Choice, whereas 51%, 16%, and 7% graded Select, Standard, and dark cutter, respectively. No carcasses graded Prime. Carcass value was six cents lower in 1997-98 ($1.00) than in 1996-97 ($1.06). Therefore, not only did the 1997-98 steers cost more than the 1996-97 steers, they were sold for less at the end of the feeding period.

The percentage English, exotic, and/or Brahman breeding were determined for each calf. Steers that were at least 50% English, no more than 50% exotic, and less than 25% Brahman were sorted into one group and those steers that did not satisfy the breed-type requirement were placed in a second group (Table 2). Calves that fit the breeding requirement graded 54% Choice compared with the calves that did not fit the breed requirement that graded 25% Choice. After reviewing the data, there appears to be enough evidence to support the recommendation that market cattle should be composed of at least 50% English, no more than 50% exotic, and less than 25% Brahman.

Listed below are the significant factors that affected net returns of steers for the 1996-97 and 1997-98 Steer Feedout Program.

1996-97

1. Dressing Percentage
2. Quality Grade
3. ADG
4. Percentage of English breeding
5. Medicine
6. Fat Thickness
7. Feed Cost of Gain

1997-98

1. Feed Cost of Gain
2. Quality Grade
3. Medicine
4. Days on Feed
5. Dressing Percentage
6. Fat Thickness

Many of the factors that affected net returns are listed in both years but in a different priority. For example, feed cost of gain was seventh in the 1996-97 program but was first in 1997-98. Other factors (quality grade and fat thickness) remained the same (2nd and 6th) both years.

1. Feed cost of gain – Feed cost of gain had a negative relationship to net return. That is, as feed cost of gain decreases, net return increases. The average feed cost of gain for the steers in the bottom 25% (based upon net returns) was $.69 per pound as compared to $.48 per pound for the steers in the top 25%. The average feed cost per pound of gain for all the steers was $.58.

2. Quality Grade – For the past two years, cattle that graded Choice, Select, Standard, and dark cutter had net returns of $78.82, $28.85, -$44.15 and -162.64, respectively. Marbling is the main factor that affects a calf's ability to grade Choice. Three main factors that affect marbling are: (1) the genetic ability to marble; (2) the maturity or the physiological age, not the chronological age; and (3) diet. Some cattle breeds report marbling EPDs in their sire summary. Carcass traits such as marbling are highly heritable; therefore, selecting high marbling EPD bulls can impact the marbling ability of their progeny. Breed type can also influence a calf's ability to grade Choice. Usually, a calf with at least one-half English breeding has an increased ability to grade Choice.

The physiological age compared to chronological age influences frame score. Large-framed cattle must be older (chronological) to reach the same physiological age to express marbling as compared to smaller-framed cattle. Therefore, feeding large framed cattle results in excessive feeding and larger carcasses. Steers should have frame scores of 5 to 6. That means that at 7 months of age a steer should be 45 to 46 inches tall at the hips.

Cattle are more likely to grade Choice when fed a high concentrate diet versus a high forage diet. Successful feedlots know how to feed cattle; therefore, the cattle diet is not a factor.

3. Medicine Cost – Healthy calves outperformed sick calves. A good preconditioning vaccination program will not guarantee a healthy feedyard calf, but it is the best management tool available.

4. Days on Feed – There was a positive relationship between days on feed and net returns. This was a function of price received. April 8 (168 days on feed) was the lowest price received whereas on April 22 (182 days on feed) was the highest price received.

5. Dressing Percentage – Dressing percentage is determined by dividing the hot carcass weight by the slaughter weight multiplied by 100. Dressing percentage is largely a function of fill and fat; thus, the fatter Prime cattle will dress from 65% to 66%. Muscling, however, can also affect dressing percent. Thickness, depth and fullness of quarter, and width (without excessive fat) of back, loin and rump are indications of muscling. Muscling or natural fleshing is inherited through the sire and dam.

The current USDA Feeder Cattle Grades use three muscle thickness scores (1=slightly thick or thicker, 2=narrow, 3=very narrow). Thickness is related to muscle-to-bone ratio and at a given degree of fatness to carcass yield grade.

Thicker muscled animals will have more lean meat. "Double-muscled" animals are included in the Inferior grade (unthrifty animals). Although such animals have a superior amount of muscle, they are graded U.S. Inferior because of their inability to produce acceptable degrees of meat quality.

The ideal calf should be Feeder Cattle Grade U.S. 1. Number 1 is thrifty and slightly thick throughout. They show a full forearm and gaskin, showing rounded appearance through the back and loin with moderate width between the legs, both front and rear.

6. Fat Thickness – Fat thickness is the number one factor that determines yield grade. Cattle that are short and have .8 inch or more fat thickness at slaughter will be discounted. Cattle less than 42 inches tall (at the hip) at seven months of age are too small.

The "frame score" is determined by measuring cattle standing naturally on a flat, firm surface, legs squarely under the body, and head in a normal position. Measurement should be made directly over the hooks or hips. This can be done with a device consisting of a cross-arm (with a bubble level) attached in a 90-degree angle to an upright. The upright contains a rule or gauge for measuring.

Frame score is a convenient way of describing the skeletal size of cattle. The current USDA Feeder Cattle Grades utilize independent evaluations of three frame sizes (Small, Medium and Large). These USDA Grades define a Medium Frame feeder steer as projected to finish at 1,000 to 1,200 pounds. Frame score 5.0 slaughter steers are estimated to average 1,150 lb at slaughter. Therefore, USDA Feeder Cattle Grade Medium is equal to frame scores 4 through 6, Small at frame scores 1 through 3 and Large at frame scores 7 through 9.

The ideal calf should be between frame scores 5 to 6. That means at 7 months of age the calf should be between 44 and 46 inches tall at the hip. It is much easier to produce frame score 5 to 6 calves from frame score 5 to 6 cows.

Table 3 summarizes the performance and carcass data from the steers that were in the bottom 25% and top 25% (based on net returns) and the average of all the steers. The five main factors that predicted net returns of steers in the bottom 25% were feed cost of gain, quality grade, medicine cost, dressing percentage, and fat thickness. In summary, the calves in the bottom 25% had high feed and medicine cost, low dressing percent and failed to grade Choice. The cattle that performed the best were medium to large framed, heavy muscled, gained well, had a high dressing percentage, did not get sick, and graded Choice.

The beef cattle industry has set the standard that quality grade should be Choice, yield grade should be 3.5 or better, and hot carcass weight between 550 and 950 lb. For the last two years of the Steer Feedout Program, only 27% of the Arkansas calves fit all those requirements. Those steers had an average net return of $84.21 whereas the steers that did not fit all the requirements had a net return of $15.74. With only 27% of the Arkansas steers filling the industry needs, it is easy to see the problem with the inconsistency and lack of quality in the beef product.

Once again, the purpose of the Arkansas Steer Feedout Program is to provide the opportunity for cow-calf producers to determine how their cattle fit with the needs of the industry. We want to congratulate the producers who participated in the 1997-98 Steer Feedout. It takes courage to put your calves in the feedyard and obtain this data. Sometimes we don't like what we find. Hopefully, these cattle producers will take this information and make beef cattle genetic changes to improve their cattle herd.

Implications

Extremes in net return, health costs, performance factors and carcass parameters exist in the beef industry. A producer's goal should be to reduce these variables and produce a product that meets the needs of all segments of the beef industry. Value-based marketing at all levels of the industry is rapidly becoming a reality. Ranchers who produce a product that meets the demands will be more competitive in the market place.

Acknowledgment

The Arkansas Steer Feedout Program would like to thank SF Services, Merial, and the Arkansas Cattlemen's Association for sponsoring the Steer Feedout Tour.

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Table 1. Comparison between the steer feedout financial summary for 1996-97 and 1997-98.

Item/year	1996-97	1997-98
Income	$770.72	$731.12
Expenses		
Feeder steer value	352.70	472.05
Feed	286.93	280.36
Medicine	3.61	8.42
Processing	10.46	11.90
Death Loss	3.71	13.25
Fees	1.40	1.40
Interest	7.20	7.90
Freight	4.50	3.92
Insurance	.64	.66
	$671.15	$799.86
Total net return	$99.57	-$68.74

Table 2. Performance and carcass data of Arkansas steers that fit the breed requirement[1] and those that did not fit the breed requirement (1996-97 and 1997-98 data combined)

	Fit the requirement	Did not fit the requirement	Significance
Percent grading Choice	54%	25%	P<.01
Yield grade	2.44	2.34	NS
Ribeye area (REA, in^2)	13.1	13.6	P<.05
REA per 100 lb. carcass weight	1.79	1.83	NS
Average daily gain (lb)	2.99	2.80	P<.01
Dressing percentage	64%	64%	NS
Feed cost per pound of gain	.52	.56	P<.01
Net return	$49.06	$32.08	NS

[1]At least 50% English, no more than 50% exotic and less than 25% Brahman.

Table 3. The performance of the bottom 25%, average, and top 25% steers based upon net return (1997-98 data).

	Bottom 25%	Average	Top 25%
Number of steers	57	229[1]	57
In weight (lb)	661	643	609
Value/cwt.	$75	$74	$72
In value	$491	$472	$438
Muscle score	1.3	1.3	1.4
Frame score			
Large	90%	73%	60%
Medium	10%	27%	40%
Final weight (lb)	1,096	1,150	1,196
Average daily gain (lb)	2.28	2.67	3.05
Gross income	$642	$740	$806
Hot carcass weight (lb)	691	742	777
Dressing percentage	63.7%	64.5%	65%
Interest	$8.41	$7.94	$7.67
Medicine	$18.92	$8.21	$2.24
Total feed cost per head	$289	$282	$278
Total expense	$335	$316	$306
Net	-$183	-$49	$62
Days on feed	193	191	193
Feed cost per lb of gain	$.69	$.58	$.48
Total cost per lb of gain	$.80	$.65	$.53
Ribeye area (in^2)	13.7	13.6	13.3
Fat thickness (in)	.29	.35	.42
Quality grade			
Prime	0%	0%	0%
Choice	9%	27%	53%
Select	32%	51%	46%
Standard	33%	16%	1%
Dark Cutter	26%	7%	0%
Yield grade	1.9	2.3	2.6

[1] Ten calves were not used in this data set. Seven calves died, two calves were railed and one carcass was condemned.

The Impact of Feeding Poultry Litter on Microbial Contamination of Beef Carcasses[1]

J.R. Davis, J.K. Apple, D.H. Hellwig, E.B. Kegley, and F.W. Pohlman[2]

Story in Brief

The objective of this study was to evaluate the effect of feeding poultry litter on the microbial contamination of beef carcasses and ground beef. Mature cull beef cows (n = 32) from the University of Arkansas Beef Unit, Savoy, Arkansas were weighed, assigned body condition scores, and randomly assigned treatment diets (as fed basis) of: 1) *ad libitum* 80% deep-stacked poultry litter and 20% corn, as well as 2 lb. long-stemmed grass hay; or 2) *ad libitum* long-stemmed grass hay. Weights and fecal samples were taken every seven days for 14 days prior to and 56 days after introduction of treatment diets. Subsequently, cattle were humanely harvested at the University of Arkansas Red-Meat Abattoir. The left side of each carcass received a 2% lactic acid rinse, and neck and bung incision samples were taken from both sides of each carcass. Trimmings from both sides of each carcass were removed and refrigerated for six days. Purge samples were taken from trimmings, trimmings were ground, and random ground beef grab samples were taken. All fecal samples, neck and bung incision samples, purge, and ground beef samples were analyzed for presence of *Salmonella* and *Escherichia coli* O157:H7 immediately after collection. No *Salmonella* or *Escherichia coli* O157:H7 were detected in any samples at any point in this experiment, except those used for positive biological controls in the laboratory.

Introduction

Over the last two decades, waste generated by animal feeding operations has begun to fall under increased scrutiny. Poultry litter is no exception, and questions arise of how to dispose of poultry litter in a manner that is both safe and environmentally friendly. Poultry litter has been used as a feedstuff for beef cattle and as a fertilizer for pasture land for many years. One of the earliest poultry litter feeding trials was published in 1955 (Noland et al., 1955). However, recent reports in the popular press have attempted to link incidence of *E. Coli* O157:H7 in ground beef to poultry litter feeding. Furthermore, Buchannan et al. (1995) reported that "a hazard analysis would conclude that *E. Coli* O157:H7 and *Salmonella* are currently the most important food borne pathogens in which raw beef could be an important vehicle." Therefore, the objective of this study was to determine whether feeding of poultry litter directly to beef cattle affects the incidence of *E. coli* O157:H7 and *Salmonella typhimurium* found on beef carcasses.

Experimental Procedures

Broiler litter was located from a local producer who cooperated fully with all sampling requirements prior to bird removal. Cloacal swabs were taken from 50 randomly selected birds prior to bird and litter removal, and drag swabs were taken from the poultry house immediately after bird removal. Approximately 15 tons of litter were purchased and transported to the U of A Beef Cattle Unit at Savoy, and stacked to a depth of 5 ft as depicted in the Arkansas Cooperative Extension Publication "Feeding Broiler Litter to Beef Cattle" (Davis, 1993.) Immediately after deep-stacking, temperature probes were inserted across the stack in order to monitor temperatures both deep inside the stack and near the surface. Samples of litter and hay were taken for proximate analysis in order to formulate treatment and control diets which were approximately equal in total digestible nutrients and adequate in crude protein and mineral content.

[1] The authors would like to express their sincere appreciation to the Arkansas Beef Council for financial support of this project. Additionally, the authors would like to thank Pete Hornsby for care of the cows, Suzanne Krumpleman, Lillie Rakes, Matt Stivarius, and Doug Galloway for assistance in cattle harvest and data collection.

[2] All authors are associated with the Department of Animal Science, Fayetteville.

Thirty-three cull cows were weighed, assigned body condition scores, and classified according to source and breed type on day -15. One cow was removed from the group due to excessive weight, and the remaining 32 cows were assigned to treatments. On day -14, cattle were weighed a second time and grab samples of feces were taken for microbial analysis. Subsequently, animals were placed into their respective pens and care was taken to avoid fence line contact between pens of animals at all times. On day -7 and day 0, cattle were weighed again and grab samples of feces were taken for microbial analysis. This concluded the two-week observation prior to introduction of the litter ration to treatment animals.

On day 0 animals were introduced to the treatment rations (as fed basis) of: 1) ad libitum 80% deep-stacked poultry litter and 20% corn, as well as 2 lbs long-stemmed grass hay per head per day, and free-choice block salt; or 2) ad libitum long-stemmed grass hay and free-choice block mineral. Furthermore, on day 0 all cattle were given a 4-mL injection of a vitamin A and D mixture containing 500,000 IU of vitamin A/mL and 75,000 IU vitamin D/ mL. On days 7, 14, 21, 28, 35, 42, 49, and 56 of the feeding trial, cattle were weighed and grab samples of feces were taken for microbial analysis.

At the conclusion of the 56-day feeding period, cows were humanely harvested at the University of Arkansas Red-Meat Abattoir. Following standard dressing procedures, both sides of each carcass were thoroughly rinsed with cold water, and the left side of each carcass received a 2% lactic acid rinse. Meat samples were removed from the neck and bung regions from both sides of each carcass for microbial analysis, and trimmings from both sides of each carcass were removed and refrigerated. After six days of refrigerated storage at 34˚F, samples of purge from lean trimmings were taken, trimmings were ground, and ground beef samples were taken for microbial analysis.

Microbial analyses were performed as follows:

***E. coli* O157:H7 from feces -** A sample of feces was placed into a tube of Lauryl Sulfate Tryptose (LST) broth with MUG and incubated. After incubation, samples were streaked for isolation on selective media. Colony morphology was compared, and typical colonies were picked and tested for indole production. Indole positive colonies were picked to LST with MUG tubes containing Durham tubes and observed for gas production and phosphorescence. Gas positive / phosphorescence negative isolates from Durham tubes were agglutinated with O157 antisera. The O157 positives were streaked on blood agar plates to facilitate the expression of the :H7 antigen, incubated, and agglutinated with :H7 antisera.

***E. coli* O157:H7 from meat -** Meat samples were stomached in buffered peptone water and incubated. A subsample of solution was placed into a tube of LST broth with MUG and incubated. After incubation, samples were streaked for isolation on selective media. Colony morphology was compared, and typical colonies were picked and tested for indole production. Indole positive colonies were picked to LST with MUG tubes containing Durham tubes and observed for gas production and phosphorescence. Gas positive/phosphorescence negative isolates from Durham tubes were agglutinated with O157 antisera. O157 positives were streaked on blood agar plates to facilitate the expression of the :H7 antigen, incubated, and agglutinated with :H7 antisera.

***Salmonella* from feces -** A sample of feces was placed into a tube of Tetrathionate broth (HAJNA) and incubated. After incubation, samples were streaked for isolation on selective media. Colony morphology was compared, and typical colonies were picked and stab-streaked in Kligler's Iron Agar (KIA) slants. The H_2S positive isolates from KIA slants were re-streaked on less selective media and agglutinated with *Salmonella* antisera.

***Salmonella* from meat -** Meat samples were stomached in buffered peptone water and incubated. A subsample of solution was placed into a tube of HAJNA and incubated. After incubation, samples were streaked for isolation on selective media. Colony morphology was compared, and typical colonies were picked and stab-streaked in KIA slants. H_2S positive isolates from KIA slants were re-streaked on less selective media and agglutinated with *Salmonella* antisera.

Results and Discussion

No *Salmonella* or *Escherichia coli* O157:H7 were detected in any samples at any point in this experiment (Table 1) with the exception of those used for positive biological controls in the laboratory for the purpose of validating experimental procedures. No *Salmonella* or *Escherichia coli* O157:H7 were detected in any cloacal swabs taken from birds in the house prior to litter removal or from drag swabs taken from the litter prior to litter removal. This is consistent with the report of McCaskey and Gurung (1998) who characterized poultry litter as an inhospitable environment for *Salmonella* and *Escherichia coli* survival due to its alkaline pH and ammonia concentration. It is also consistent with the findings of Martin and McCann (1998) who found no *Salmonella* or *Escherichia coli* O157:H7 in any of 86 samples of poultry litter from the state of Georgia. No *Salmonella* or *Escherichia coli* O157:H7 were detected from any fecal samples at any point. Additionally, no *Salmonella* or *Escherichia coli* O157:H7 were detected from neck and bung incision samples, trimming purge samples, or ground beef samples at any point during this experiment.

Implications

Although not expressly encouraged by the Food and Drug Administration, the feeding of poultry litter to beef cattle has not been demonstrated to be harmful to beef cattle. Furthermore, as this study has demonstrated, feeding poultry litter to cull beef cows does not increase the incidence of

Salmonella or *Escherichia coli* O157:H7 on beef carcasses or in ground beef.

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Table 1. Isolation of *E. coli* O157:H7 and *Salmonella.*

	Bacterial incidence			
	Control		Litter-fed	
Sample	*E. coli* O157:H7	*Salmonella*	*E. coli* O157:H7	*Salmonella*
Fecals	none detected	none detected	none detected	none detected
Non-lactic acid-rinsed				
Neck	none detected	none detected	none detected	none detected
Bung	none detected	none detected	none detected	none detected
Trim purge	none detected	none detected	none detected	none detected
Ground beef	none detected	none detected	none detected	none detected
Lactic acid-rinsed				
Neck	none detected	none detected	none detected	none detected
Bung	none detected	none detected	none detected	none detected
Trim purge	none detected	none detected	none detected	none detected
Ground beef	none detected	none detected	none detected	none detected

Effect of Shade Type on Cow Growth Performance

Ken Coffey[1], Don Hubbell, III[2], and Kenneth Harrison[2]

Story in Brief

Providing adequate shade for cows can be a problem in modern grazing systems. Previous work has shown no detrimental effect of depriving stocker calves of shade, but cattlemen are concerned it may be a problem for cows. Twenty-four gestating, fall-calving Brangus-cross cows were used to compare performance of cows provided no shade to that of cows provided shade from either an artificial (metal roof) or natural (tree) source. The study was conducted during three consecutive 21-day periods beginning June 11. The cows were divided into six groups. The groups were originally allocated to six pastures; two had no shade, two had artificial shade, and two had natural shade. At the end of each period, cows were rotated to a different shade treatment. Cows having access to trees rather than no shade or artificial shade numerically ($P > .10$) gained more weight (1 lb/day). Variability in response observed in this study prevented detection of statistical differences. However, the responses observed raises concerns about gestating cows grazing pastures without shade during the summer.

Introduction

Previous studies evaluating the impact of shade on cattle performance have been variable. Work in southeast Kansas reported that calves having no access to shade tended ($P > .10$) to gain .14 lb/day faster than calves having access to natural shade (Coffey et al., 1994). Personal observations with stocker cattle indicate that those not having access to shade tended to spend more time grazing during the middle of the day while those having access to shade stood or rested in the shade. As producers attempt to use forage more efficiently through some form of a controlled grazing program, the availability of shade in each small pasture becomes a problem. The objective of this study was to compare natural and artificial shade with no shade on the growth performance of cows grazing bermudagrass in the summer.

Experimental Procedures

Beginning at 4 pm on June 11, 24 Brangus-cross cows were removed from pasture, weighed, and held without feed and water until 8 am on June 12. Cows were then weighed and allotted randomly, based on weight, to one of six groups. Each group of cows was assigned to one of six bermudagrass pastures. Two pastures each had either 1) no shade, 2) artificial shade, or 3) natural shade. Artificial shades were permanent structures of sheet metal on top of a pole structure that was at least 10 ft high. Natural shade consisted of at least one tree of mature size that would provide ample shade for the entire group of cows to stand under. Pastures were 5 acres in size and were fertilized according to soil test recommendations. On July 2 and 23 at 4 pm, cows were removed from pastures, weighed, and held without feed and water until 8 am the next morning. Cows were then weighed and relocated to another pasture with a different shade treatment, so that each group of cows would be exposed to each shade treatment for 21 days. The study was terminated on August 14.

Results and Discussion

Cows with access to natural shade gained 1 lb/day faster ($P = .32$) than those with access to artificial shade or no shade (Table 1). Failures to detect statistically significant differences were due possibly to excess variability among experimental units and variability in weather conditions. Treatment differences were observed in periods one and two (Table 2). Cows having access to natural shade gained more ($P < .10$) than those having access to artificial shade in periods one and two and those not having access to shade in period two. Temperatures during the last week of period 3 (August 7 - 13) were below those encountered during the previous three weeks (Table 3). Also, measurable rainfall occurred during five of the last seven days of period 3 implying more cloud cover and potentially less solar radiation stress on the cows. It is possible these factors resulted in a more favorable environment for the cows, resulting in no treatment differences during period 3. Lack of treatment differences during period

[1] Department of Animal Science, Fayetteville.
[2] Livestock and Forestry Branch Experiment Station, Batesville.

3 reduced the combined treatment differences observed. This also increased overall treatment variability. All pastures appeared to have excess available forage as determined by visual appraisal.

In a previous study evaluating shade effects on stocker cattle (Coffey et al., 1994), cattle remained on a particular shade treatment throughout a 112-day experiment, rather than being subjected to each treatment. In this study, cows were exposed to each treatment for a 21-day period. This could impact the results, since the cows might adapt to the lack of shade if they were without shade for the duration of the study. However, this experimental method imitates situations in which cows are moved into and out of pastures with shade.

Implications

Based on this information, although not statistically significant, it appears that natural shade may be necessary for optimal cow weight gain. Furthermore, artificial shade may not sufficiently reduce the impact of heat stress. Therefore, in designing controlled grazing systems, care should be taken to insure that natural shade is available for cows during the summer months.

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Table 1. Gain by cows exposed to different shade treatments[a].

	No shade	Artificial shade	Tree shade	P value
ADG (full)	1.95	2.04	3.09	.32
Wt change (full)	41.00	43.00	65.00	.33
ADG (shrunk)	1.47	1.80	2.34	.28
Wt change (shrunk)	31.00	38.00	49.00	.28
Percentage of shrink	6.20	5.90	6.00	.60

[a]No statistical differences were detected (P < .10).

Table 2. Daily gain by period from cows exposed to different shade treatments.

	No shade	Artificial shade	Tree shade	P value
Period 1 (June 12-July 1)	3.75[ab]	2.59[b]	5.12[a]	.076
Period 2 (July 2-July 22)	.50[b]	.84[b]	2.39[a]	.080
Period 3 (July 23-August 14)	1.59	2.70	1.77	.214

[a,b] Means within a row without a common superscript letter differ (P < .10).

Table 3. Average high and low ambient temperature and measurable precipitation by period when cows were exposed to different shade treatments.

	Low Temp. °F	High Temp. °F	Precip. inches	No. of Precip. days
June 12-June 18	87.3	64.4	0.70	3
June 19-June 25	93.9	70.9	0.00	0
June 26-July 2	94.4	68.4	0.44	4
Period 1 average (June 12-July 2)	91.9	67.9	1.14	7
July 3-July 9	90.7	63.4	0.09	3
July 10-July 16	96.0	70.1	0.19	2
July 17-July 23	98.6	71.3	0.06	1
Period 2 average (July 3-July 23)	95.1	68.3	0.34	6
July 24-July 30	98.7	73.6	1.42	3
July 31-August 6	93.0	63.7	0.00	0
August 7-August 13	89.6	66.1	1.03	5
Period 3 average (July 24-August 13)	93.5	67.6	2.45	8

Performance of Fall-Calving Cows Fed Zeolite While Grazing Fescue During the Winter[1]

Ken Coffey[2], Don Hubbell[3] Charles Rosenkrans, Jr.[2], Wayne Coblentz[2], Zelpha Johnson[2], and Kenneth Harrison[3]

Story in Brief

A number of products have been tested that potentially bind to tall fescue toxins. One hundred twenty-eight fall-calving cow/calf pairs (1108 and 305 lb for cows and calves, respectively) grazing tall fescue pastures were allocated to supplements containing either no supplemental zeolite, or zeolite supplemented at .3 or .6 lb/day during 56-day winter grazing studies conducted for two years. Supplements were fed Monday through Friday. No treatment differences were observed for cow or calf gain, cow body condition score change, or milk production. Therefore, the zeolite evaluated in this study does not appear to positively impact production by cows grazing endophyte-infected fescue pastures in the winter.

Introduction

Infection of tall fescue with the endophytic fungus *Neotyphodium coenophialum* causes reduced milk production, weight gain, and conception rates of cows (Ashley et al., 1987). Although certain mined clays have been shown to bind the toxins produced by this endophytic fungus, only a limited number of these binding agents actually bind to those toxins in the rumen environment because of the abundance of other compounds present in rumen fluid. Compounds that have been successful in binding fescue toxins from rumen fluid have been evaluated in production situations to a very limited extent (Samford et al., 1993). The objective of this study was to determine the effect of feeding different levels of a zeolite that was shown to bind fescue toxins on weight and body condition score changes and milk production by cows and growth of calves grazing endophyte-infected stockpiled fescue.

Experimental Procedures

Winter grazing studies were conducted in 1997 and 1998 beginning in mid-January, using a total of 128 fall-calving cows and their calves. Cows and calves were weighed on two days in mid-January of each year without prior removal from pasture and water and assigned randomly by weight and age to one of eight endophyte-infected fescue pastures (12.3 to 14.5 acres each). Pasture groups were assigned randomly to the following treatments: 1) 3 lb/day of a rice bran-based control supplement (two groups), 2) 3 lb/day of the rice bran supplement with .3 lb of zeolite added daily (three groups), or 3) 3 lb/day of the rice bran supplement with .6 lb of zeolite added daily (three groups). Supplements were fed Monday through Friday. Milk production was measured by the weigh-suckle-weigh technique on day 28 during both years of the study. The weigh-suckle-weigh technique consisted of separating cows from calves for approximately 12-hours, allowing calves to nurse cows to remove milk then separating them again for approximately 16 hours. Calves were held in pens without access to feed or water during the separation period, and cows were allowed to graze a common pasture of mixed forages. Calves were weighed, reunited with their dams for approximately 20 minutes, then weighed again when ceased nursing the cows. Body condition scores were evaluated by an experienced technician at the beginning and end of the study. Cattle groups were moved throughout the eight pastures at 14-day intervals to minimize the impact of pasture variation on animal production. Cows and calves were weighed without prior removal from pasture and water on two days at the end of the 56-day grazing period. Data were analyzed statistically using PROC MIXED procedures of SAS (1988).

Results and Discussion

Although differences in animal performance between years was detected ($P < .05$) the year x treatment interaction was not significant ($P > .10$) for any of the measurements reported. Therefore, main effects of treatment were averaged across years and presented in Table 1. No differences ($P >$

[1] Appreciation is expressed to Armbruster Consulting, Amarillo, Texas for providing the experimental zeolite and to Riceland Foods, Stuttgart, Arkansas for providing rice bran for the study.
[2] Department of Animal Science, Fayetteville.
[3] Livestock and Forestry Branch Experiment Station, Batesville.

.10) were detected for cow or calf weight or milk production. Likewise, no differences were detected in cow body condition score change. Since no differences among treatments were detected in either year, it is unlikely that this particular zeolite will alleviate the depressions in cow and calf growth performance caused by consuming infected fescue forage. Possible reasons for this are 1) the zeolite used in this study may not be effective in binding sufficient quantities of toxins; 2) the fescue toxicity problem may not have been severe enough during the winter period to illicit a gain response, 3) the fescue toxicity problem was manifested in other symptoms not measured in this experiment, or 4) the zeolite used in this study may have some detrimental effects by binding beneficial nutrients, thus off-setting any beneficial aspects (Mumpton and Fishman, 1977). In either case, zeolite was ineffective in increasing weight gain by cows and calves grazing winter fescue.

Implications

Numerous products are available that have shown potential to offset fescue toxicity in controlled laboratory and in vitro situations. To date, most of these have failed to benefit animals in production situations. Specific zeolites may bind tall fescue toxins, but their ability to reduce the impact of tall fescue toxins is probably minimal during the winter grazing period. Therefore, products claiming to bind tall fescue toxins should be evaluated under production situations to determine their use.

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Table 1. Effect of zeolite supplementation on cow and calf performance two-year average.[a]

Item	Control	.3 lb/day	.6 lb/day	SE
Cows:				
Initial wt, lb	1113	1103	1107	16.9
Final wt, lb	1074	1055	1056	16.5
Gain, lb	-39	-48	-51	6.3
Initial body condition score	5.5	5.6	5.3	.11
Body cond. score change	-.03	-.10	.07	.102
Milk production, lb	8.0	7.5	7.4	.91
Calf:				
Initial wt, lb	306	302	306	8.7
Final wt, lb	398	398	401	10.5
Gain, lb	92	96	95	3.4
Daily gain, lb	1.63	1.71	1.70	.060

[a]No significant differences were detected (P < .10).

Performance of Stocker Calves Backgrounded on Winter Annuals or Hay and Grain[1,2]

Ken Coffey[3], David Shockey[4], Wayne Coblentz[3], Charles Rosenkrans, Jr.[3], Stacey Gunter[5], and Greg Montgomery[6]

Story in Brief

A two-year study involving 120 crossbred calves (574 lb) was conducted during the winters of 1998 and 1999 to compare winter backgrounding programs in southeastern Arkansas. Calves were fed either bermudagrass hay and a grain sorghum-based supplement or grazed pastures of bermudagrass and dallisgrass that were overseeded with 1) annual ryegrass, 2) wheat and ryegrass, or 3) rye and ryegrass for 112 days beginning in mid-December of each year. Calves fed the hay + supplement treatment gained less weight ($P < .05$), and had a higher cost of gain, and lower return per head than calves that grazed the winter annual forages. Cost of gain was lowerand return/head was higher ($P < .05$) for annual ryegrass than for rye+ryegrass while that of wheat+ryegrass was intermediate and did not differ ($P > .10$) from either of those two treatments. Winter annual forages offer potential to increase the profitability of stocker calves in southern Arkansas by retaining ownership until spring. Stocker programs involving only grain and hay during the winter and spring are probably not profitable.

Introduction

Winter backgrounding programs for stocker calves involving hay and supplemental grain are expensive both per day and per pound of gain produced. An alternative is to overseed existing warm-season grass pastures with winter annual forages. Considerable research has been conducted in the lower south with winter annuals as forage. Responses to these systems in Arkansas differ because of colder winter temperatures and a shorter fall growing season. The objective of this study was to evaluate growth and economic return from calves grazing pastures overseeded with annual ryegrass, wheat and ryegrass, or rye and ryegrass compared with those of calves fed bermudagrass hay and supplemental grain in drylot during winter and spring.

Materials and Methods

One hundred twenty crossbred calves (574 lb) were used in a two-year grazing study during the winter months of 1997 and 1998. Calves were weighed on two consecutive days in mid-December of 1997 and 1998, stratified by weight and sex, and allocated randomly to 1 of 12 groups of five head each. In 1997, four groups were heifers and eight groups were steers. One group of heifers and two groups of steers were placed on one of four backgrounding programs. In 1998, one group of steers, one group of heifers, and one group of mixed steers and heifers were allocated to each treatment. Three winter annual forage treatments consisted of grazing 5-acre bermuda/dallisgrass pastures that were overseeded with 1) 30 lb/acre of 'Marshall' ryegrass, 2) 30 lb/acre of Marshall ryegrass plus 120 lb/acre of 'Madison' soft wheat, or 3) 30 lb/acre of Marshall ryegrass plus 100 lb/acre of 'Bonel' rye. In a fourth backgrounding treatment, calves were placed on dormant bermudagrass pastures and fed bermudagrass hay *ad libitum* plus a grain sorghum supplement. All calves had been weaned and vaccinated in October prior to beginning the grazing period.

Pastures were disked lightly with the disk angle removed from the disk and were overseeded by broadcasting the respective forages in late-September. Pastures were then harrowed lightly to help incorporate seed. Fifty lb/acre of nitrogen, phosphate, and potash were applied in late-November. An additional 50 lb/acre of nitrogen was applied in early February.

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[1] Appreciation is expressed to Boehringer Ingelheim Vetmedica, Inc. for providing cattle vaccinations and to Ft. Dodge Animal Health, Inc. for providing dewormer.

[2] Mention of specific varieties does not imply endorsement by the Division of Agriculture of those named varieties, nor does it imply criticism of other such varieties that are not mentioned.

[3] Department of Animal Science, Fayetteville.

[4] Former Research Specialist. Southeast Research and Extension Center, Monticello.

[5] Southwest Research and Extension Center, Hope.

[6] Research Specialist. Southeast Research and Extension Center, Monticello.

Calves grazing the winter annual pastures were fed 2 lb/head daily of a grain sorghum-based supplement containing trace mineral salt, necessary minerals, and monensin (200 mg/head). Calves fed bermudagrass hay (11.7% crude protein, 58% TDN) were also fed a ground grain sorghum-based supplement at 1% of body weight and cottonseed meal at .65 lb/day. The supplement contained trace mineral salt, limestone, and monensin (200 mg/head). Square bales of bermudagrass hay were fed daily in feed bunks to provide ad libitum consumption.

Interim weights were measured without prior removal from feed and water at 28-day intervals throughout the study. Calves were weighed without prior removal from feed and water on two consecutive days in early April to determine ending weights. Costs associated with the different backgrounding programs were determined using the costs presented in Table 1. Available forage was measured monthly by clipping three random 20" x 20" areas per pasture. Statistical analyses were conducted using SAS (1988) procedures for a repeated measures analysis of variance.

Results and Discussion

Total weight gain and return ($/head) were greater ($P < .05$) and cost of gain was lower ($P < .05$) from calves grazing annual forages compared with those fed hay and grain (Table 2). Weight gains did not differ ($P > .10$) among the annual forage treatments, but cost of gain was lower ($P < .05$) and return was higher ($P < .05$) from calves grazing annual ryegrass compared with those grazing rye+ryegrass. Cost of gain ($/cwt) and return ($/head) from calves grazing wheat+ryegrass was intermediate among the winter annual treatments and did not differ ($P > .10$) from either those grazing ryegrass or those grazing rye+ryegrass. Gain during the first and last 28 d of the experiment was lower ($P < .05$) from calves fed hay and grain compared with those grazing annual forages. Calf gain during the two remaining 28-day periods did not differ ($P > .10$) among treatments. Overall gain by calves grazing sod-seeded winter annual pastures are comparable to those from other studies (Moyer et al., 1995). Diets for calves fed hay and grain were formulated based on feeding 1% of body weight as ground grain sorghum and were estimated to produce 1.5 lb/day gain. Average hay consumption was 8.6 lb/day. Increasing levels of supplemental grain have been shown to have a negative impact on forage intake and cost efficiency (Goetsch et al., 1991; Freeman and Coffey, 1993).

Average available forage ranged between 800 and 1250 lb/acre. Although 800 lb/acre is considered somewhat limiting for optimal animal intake, weight gains did not reflect a restriction in intake. Therefore, the annual forage treatments offer the potential to provide economical gain on calves weaned in the fall and held through the winter.

Implications

Winter annual grazing programs have been tried in various locations with variable success. One key to success for these programs is to have adequate forage to graze as early as possible in the fall. This may be difficult to achieve in sod-seeding situations. However, the options evaluated in this study demonstrate that disking pastures and using annual ryegrass alone or in combination with rye or wheat may provide winter grazing for fall-weaned calves to produce economical weight gain allowing cattle producers in southeastern Arkansas to obtain a profit by retaining ownership of their calves.

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Table 1. Costs used in calculating economic returns for different backgrounding programs in southeast Arkansas.

Item	Cost/unit
Cattle processing, $/head	10.00
Grain sorghum supplement, $/cwt	4.75
Hay, $/cwt	2.00
Cottonseed meal, $/cwt	10.00
Ammonium nitrate, $/cwt	9.45
19-19-19 fertilizer, $/cwt	7.50
Spreading cost (each spreading), $/acre	2.50
Rye seed, $/cwt	17.00
Wheat seed, $/cwt	6.00
Ryegrass seed, $/cwt	38.00
Seeding cost, $/acre	10.00
Interest rate, %	9.0
Assumed death loss, %	1.0

Table 2. Weight and gain by steers on different backgrounding programs in southeast Arkansas.

	Hay + Supplement	Ryegrass	Rye + Ryegrass	Wheat + Ryegrass	SE
Initial wt., lb	573	572	574	575	5.9
Weight, lb, at:					
d 28	573[b]	616[a]	617[a]	613[a]	9.2
d 56	632[b]	676[a]	682[a]	665[a]	17.1
d 84	703	758	759	739	20.4
d 112	732[b]	836[a]	817[a]	813[a]	16.3
Gain, lb	158[b]	265[a]	242[a]	237[a]	15.9
Daily gain, lb	1.42[b]	2.36[a]	2.16[a]	2.12[a]	.142
Cost, $/cwt gain	77.21[a]	39.12[c]	51.15[b]	46.26[bc]	3.802
Return, $/head	-40.25[c]	27.80[a]	-0.98[b]	11.02[ab]	9.359
Gain, lb					
d 0-28	0[b]	44[a]	44[a]	37[a]	6.9
d 29-56	59	60	65	52	10.8
d 57-84	71	82	77	74	7.5
d 85-112	29[b]	78[a]	58[a]	74[a]	7.4

[a,b,c] Means within a row without a common superscript letter differ (P < .05).

Effect of Pre-Weaning and/or Pre-Vaccination on Weight Change During the Weaning Process[1]

Ken Coffey[2], Dianne Hellwig[2], Charles Rosenkrans, Jr.[2], Wayne Coblentz[2], Don Hubbell, III[3], Zelpha Johnson[2], Kenneth Harrison[3], and Butch Watson[2]

Story in Brief

One hundred forty-four fall-born calves (444 lb initial body weight [BW]) were used in a two-year study to evaluate the impact of pre-shipment vaccination and/or weaning on weight change of calves at different times during the weaning process. Calves were allocated randomly by weight and sex into eight groups each year. Half of the calves within each group received vaccinations against infectious bovine rhinotracheitis (IBR), bovine virus diarrhea (BVD), parainfluenza (PI_3), bovine respiratory syncytial virus (BRSV), five strains of *Leptospira* sp., *H. somnus*, and *Pasturella haemolytica* on day 0 (EV) and half were not vaccinated until day 29 (LV). Half of the groups of calves were weaned on day 14 of the study (EW), and half of the groups were weaned on day 28 (LW). All calves were loaded and transported to a local auction barn on day 28 and brought back to the station and vaccinated on the morning of day 29. Early-weaned calves that were not vaccinated prior to shipping had lower ($P < .05$) gain from day 0 until the morning of shipping than calves on the other treatments in year one. Those calves (EW-LV in year one) also gained less from day 0 until weighing at the auction barn than EV calves that were either late or early weaned. No differences in weight gain were detected ($P > .10$) in year 2. Early-weaned calves lost more ($P < .10$) weight between being weighed at the auction barn and return to the research station and required more ($P < .05$) days to regain transit weight loss than late-weaned calves. Therefore, weaning calves two weeks prior to shipping them to an auction barn appears to provide little benefit, but vaccinations four weeks prior to shipping could result in extra weight for calves sold.

Introduction

In a recent survey of cattlemen from 25 different states, animal health was rated as the most important criteria in determining profitability of stocker or feeder cattle (Neal et al., 1998). Numerous pre-weaning vaccination programs have been established in different states to encourage producers to produce healthier calves for buyers. Acceptance of these programs by cow-calf producers has been less than desirable because of lack of a perceived premium for preconditioned calves. The purpose of this study is to evaluate calf management methods to 1) reduce weight loss during weaning, 2) to reduce stresses associated with weaning, and 3) to increase animal resistance to foreign pathogens contacted at an auction barn environment.

Experimental Procedures

A total of 144 fall-born suckling calves grazed with their dams in eight groups of eight (1998) or 10 (1999) head each on eight different pastures of *Neotyphodium coenophialum*-infected fescue. Calves were allocated randomly to four treatments in a 2 x 2 factorial arrangement of a split-plot experiment to compare early (EW) with late weaning (LW) and pre-weaning vaccination (EV) with no pre-weaning vaccination (LV). Half of the calves within each group were dewormed and vaccinated against infectious bovine rhinotracheitis (IBR), bovine virus diarrhea (BVD), parainfluenza (PI_3), bovine respiratory syncytial virus (BRSV), five strains of *Leptospira* sp., *H. somnus*, and *Pasturella haemolytica* on day 0 (28 days prior to shipping all calves to a local auction barn) of the study and half of the calves were not vaccinated against these organisms until they returned from an auction barn on day 29. All calves were vaccinated against clostridial infections on day 0.

Four groups of calves each year were weaned in a drylot on day 14 and fed bermudagrass hay with 4 lb/day of a rice bran supplement. At 7:00 am on day 28, all calves were gathered, weighed, transported approximately 10 miles to an auction barn, and placed in pens without feed and water. Calves were weighed at approximately 8:30 pm then placed in pens with access to water only.

[1] Appreciation is expressed to Boehringer Ingelheim Vetmedica, Inc. for providing vaccines.

[2] Department of Animal Science, Fayetteville.

Calves were returned to the research facility on the morning of day 29. Calves previously dewormed and vaccinated received a booster vaccination against the previously-mentioned organisms. Those calves that were not vaccinated previously were dewormed and received their first vaccination against the aforementioned organisms. All calves were weighed and placed in eight drylot pens by treatment group. Calves were fed hay to appetite and fed a supplement of rice bran and minerals at a level of 4 lb/head daily.

All calves were weighed on day 32 and moved to pastures of common bermudagrass overseeded with rye and annual ryegrass (1998) or orchardgrass (1999). Rice bran and mineral supplementation was continued for 21 days. Calves were observed daily for 21 days for signs of illness and treated when their temperature reached or exceeded 104° F. Calves receiving their first vaccination on day 29 received a booster vaccination on day 50 of the study.

Weight data were analyzed by analysis of variance (PROC MIXED; SAS, 1990) using initial weight as a covariate. Morbidity data were analyzed by Chi-Square analysis.

Results and Discussion

A year x weaning treatment x vaccination treatment interaction was detected ($P < .10$) for most of the weight and gain variables. In 1998, auction-barn weights and weights when the calves returned to the station were lower ($P < .05$) from EW-LV than for the other treatments (Table 1). Those calves also weighed less ($P < .05$) than EW-EV and LW-EV calves prior to shipping them to the auction barn. No differences in calf weights were detected ($P > .10$) in 1999.

Gain data (Table 2) followed similar patterns as were observed for animal weight. In 1998, calves weaned early and not vaccinated until day 29 (EW-LV) gained 17, 11, and 15 lb less ($P < .05$) prior to shipping than EW-EV, LW-LV, and LW-EV calves, respectively. Weight gain from day 0 until day 50 was greater ($P < .05$) from LW-LV and LW-EV compared with EW-LV.

The 3-way interaction was not detected ($P > .10$) for weight losses resulting from transportation to and from the auction barn (Table 3). Calves not weaned prior to transport lost 3 lb less weight ($P < .10$), shrank .6% less ($P < .10$) and required 2.9 fewer ($P < .05$) day to regain weight lost during transportation than calves weaned two weeks prior to transportation, regardless of vaccination treatment. Vaccine treatment did not impact weight loss during transit to, during, and from the auction barn.

Morbidity rate did not differ ($P > .10$) among treatments (Table 4). In 1998, EV calves numerically had lower morbidity than LV calves, but these trends did not hold in 1999. Early weaned calves had numerically higher morbidity in 1998 and numerically lower morbidity in 1999.

When averaged across years, the results in this study show some benefits of early vaccination but not of weaning calves two weeks prior to transporting them to an auction facility. It also shows that response to these programs varies under different circumstances. Calves were weaned in mid-May in 1998. During that time, ambient temperatures were high and animals displayed symptoms of heat stress during the weaning process. In 1999, calves were weaned in mid-April during more moderate temperatures. It is possible that less environmental stress in 1999 negated treatment differences. It is also possible that two weeks is insufficient time to allow calves to recover prior to additional stresses of transport to an auction facility. If this is the case, calves that are early weaned are subjected to multiple stressors over an extended period rather than one stress over a shorter period.

Calves in this study were exposed to some but not all of the stresses normally presented to weaned calves. Although calves were transported to an auction facility, they were exposed only to calves on either side of the pen they were housed in. In many situations, calves are commingled with calves from numerous locations, thereby exposing them to multiple organisms. This reduced exposure is the probable reason for a somewhat lower morbidity than expected in these studies. With reduced morbidity, response to treatments would be expected to also be reduced.

Implications

Producing healthy calves should be a high priority for Arkansas producers based on recent surveys. Responses to pre-weaning vaccination programs will probably be based on the level of stress and disease exposure to which calves are subjected. Weaning calves two weeks prior to shipping will probably provide little additional benefit to the seller other than their cattle might spend less time bawling at the auction barn. However, vaccination against respiratory infection prior to transport may improve weight gain and should provide immunity when calves are exposed to stressful situations.

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Table 1. Weight (lb) of stocker calves at various times during the weaning process that were vaccinated early or late and weaned early or late.

	Early wean		Late wean		
	Early vac	Late vac	Early vac	Late vac	SE
1998					
day 14	486[a]	477[b]	484[ab]	482[ab]	4.3
day 28 (7 am pre-ship)	500[a]	483[b]	498[a]	494[ab]	5.2
day 28 (8 pm at salebarn)	489[a]	475[b]	489[a]	484[a]	4.5
day 29 (at research station)	472[a]	457[b]	474[a]	471[a]	4.3
day 50	521[bc]	512[c]	540[ab]	550[a]	8.0
1999					
day 14	475	480	477	475	3.9
day 28 (7 am pre-ship)	506	513	513	509	4.9
day 28 (8 pm at salebarn)	490	496	495	491	4.3
day 29 (at research station)	468	473	475	471	4.0
day 50	541	548	543	532	7.6

[a,b,c]Means within a row without a common superscript letter differ (P < .05).

Table 2. Gain (lb) by stocker calves at various times during the weaning process that were vaccinated early or late and weaned early or late.

	Early wean		Late wean		
	Early vac	Late vac.	Early vac	Late vac	SE
1998					
day 0-14	42[a]	33[b]	40[ab]	38[ab]	4.1
day 0 - pre-ship	55[a]	38[b]	53[a]	49[a]	5.2
day 0 - salebarn	44[a]	30[b]	44[a]	39[ab]	4.5
day 0 - 50	76[bc]	67[c]	95[ab]	105[a]	8.0
1999					
day 0-14	31	36	33	31	3.9
day 0 - pre-ship	61	68	68	64	4.9
day 0 - salebarn	45	51	50	46	4.3
day 0 - 50	96	103	98	87	7.6

[a,b,c]Means within a row without a common superscript letter differ (P < .05).

Table 3. Weight loss, percentage shrink, and time required to regain lost weight by stocker calves at various times during the weaning process that were vaccinated early or late and weaned early or late.

	Wean treatment		Vaccine treatment		
	Early wean	Late wean	Early vac	Late vac	SE
Weight loss, lb					
Pre-ship – salebarn	14	13	14	13	1.0
Salebarn – station	20[a]	17[b]	19	18	1.0
Pre-ship – station	33	31	32	32	1.2
% Shrink					
Pre-ship – salebarn	2.7	2.8	2.8	2.7	.20
Salebarn – station	4.1[a]	3.5[b]	3.8	3.9	.20
Pre-ship – station	6.7	6.2	6.7	6.2	.22
Shrink recovery time, days	8.1[c]	5.2[d]	6.3	6.9	.77

[a,b]Means within a row and main effect of wean or vaccination treatment without a common superscript letter differ ($P < .10$).
[c,d]Means within a row and main effect of wean or vaccination treatment without a common superscript letter differ ($P < .05$).

Table 4. Morbidity (%) of stocker calves at various times during the weaning process that were vaccinated early or late and weaned early or late[a].

	Wean treatment		Vaccine treatment	
	Early wean	Late wean	Early vac	Late vac
1998	21.9	9.4	9.4	21.9
1999	12.5	37.5	27.5	22.5
Total	16.7	25.0	19.4	22.2

[a]No significant differences were detected ($P < .10$) by Chi-Square analysis.

Effect of Agrado® on Performance and Health of Calves New to the Feedlot Environment[1]

Beth Kegley[2], Dianne Hellwig[2], Don Gill[3], and Fred Owens[3]

Story in Brief

Two experiments were conducted to determine the effect of an antioxidant (Agrado®) on the growth, feed:gain ratio, and health of receiving calves. In Experiment 1, 96 heifer calves were purchased at sale barns and delivered as one group to the research facility in Savoy, Arkansas. All heifers were fed a totally mixed ration containing cottonseed hulls, cracked corn, and soybean meal for 42 days. Treatments consisted of 0 or 150 ppm Agrado. Fewer ($P < .05$) of the heifers fed supplemental Agrado became sick (73 vs. 83%); therefore, medication costs were lower ($P < .05$) for heifers fed supplemental Agrado ($6.32 vs. 9.49). Average daily gain and feed:gain ratio were not affected ($P > .10$). In Experiment 2, 86 bull and steer calves were purchased at sale barns. Bulls were castrated after arrival at Savoy. Steers were managed and fed as in Experiment 1 for this 41-day study. There was no significant effect ($P > .10$) of dietary treatment on the number of sick calves or medication costs. Supplemental Agrado improved ($P < .04$) feed:gain ratio for the first 28 days. Supplementation with Agrado improved the health of receiving cattle in one of two experiments; feed:gain ratio was improved during the first 28 days in the other experiment.

Introduction

Dysfunction of the immune system results in significant annual losses to livestock producers. Morbidity is a costly economic problem that may, in part, be addressed by nutritional intervention. Nutritional status can have profound effects on immune function; energy, protein, minerals, and vitamins all can affect immunocompetence.

Oxidants (including free radicals) can damage animal tissues. Oxidants are produced during metabolism; oxidant production may increase with detoxification of many compounds, exercise, stress, tissue injury, and infection. The ratio between antioxidants and free radicals may become unbalanced under such conditions. Antioxidant nutrients include: vitamin E, β-carotene, and the trace elements (selenium, copper, zinc, iron and manganese) acting as components of enzymes.

An antioxidant mixture commercially available to the feed industry is Agrado® (Solutia Inc., St. Louis, Missouri). The primary chemical in this product is ethoxyquin. Ethoxyquin has been used for many years as a feed preservative. It also extends the shelf-life of poultry meat. No research has been published on the effects of this compound on bovine immune function or growth performance. Therefore, the objective of these experiments was to determine the effect of supplementing Agrado in the receiving ration on growth performance and immune function of transport-stressed calves.

Experimental Procedures

Experiment 1. Ninety-six mixed breed heifer calves (454 ± 3.1 lb initial BW), purchased at sale barns by an order buyer, were delivered as one group to the University of Arkansas Stocker and Receiving Cattle Research facility on December 4, 1997. Heifers were injected with clostridial and viral respiratory vaccines, a pour-on insecticide was used, and any horns were tipped. All heifers were branded and identified with ear-tags. Heifers were allocated randomly within eight weight blocks to two dietary treatments, with six heifers in each of 16 pens for a total of 48 heifers per treatment.

All heifers were fed a totally mixed ration formulated to meet NRC (1996) recommendations (Table 1). Dietary treatments consisted of 0 or 150 ppm Agrado. Heifers were observed daily during the 42-day study for signs of morbidity. Rectal temperature (≥ 104°F) and clinical signs were used to identify morbid calves. Calves with rectal temperatures ≥ 104°F were treated with antibiotic(s) following a preplanned protocol. If animals did not respond to the first antibiotic administered, the next antibiotic in the protocol was used. Success of antibiotic treatment was examined by a drop in body temperature of at least 2°F within 24 hours, along with remission of clinical signs and return to normal activity.

Body weights were obtained upon arrival and on day 14, 26, and 42. Feed intakes were recorded daily and heifers

[1]Appreciation is expressed to Solutia Inc. for providing financial assistance for this project.
[2]Department of Animal Science, Fayetteville
[3]Department of Animal Science, Oklahoma State University, Stillwater

were bled via jugular venipuncture on day 0, 26, and 42. Serum was analyzed for antibody response to infectious bovine rhinotracheitis virus, bovine viral diarrhea, and parainfluenza-3 virus vaccines.

Experiment 2. Eighty-six mixed breed bull and steer calves (522 ± 4.9 lb initial BW), purchased at sale barns by an order buyer, were delivered as one group to the University of Arkansas Stocker and Receiving Cattle Research facility on March 18, 1998. Bulls were castrated after arrival. Steers were managed and fed as in Experiment 1. Dietary treatments were the same as in Experiment 1 for this 41-day study. Steers were allocated randomly within eight weight blocks to dietary treatment, with six steers in each of six pens and five steers in each of 10 pens, for a total of 43 steers per treatment. Body weights were taken upon arrival and on day 7, 14, 28, and 41. Feed intakes were recorded daily.

Statistical Analysis. Data from both experiments were analyzed with analysis of variance as a randomized complete block design (SAS, 1988). Pen was used as the experimental unit for all analysis

Results

Experiment 1. Fewer ($P < .05$) of the heifers fed supplemental Agrado became sick (Table 2); therefore, medication costs were lower ($P < .04$) for heifers fed supplemental Agrado. No significant ($P > .10$) effects of supplementation were detected on the number of calves becoming sick a second time or on the day that first illness occurred. No differences ($P > .10$) due to dietary treatment were observed for serum antibody response to infectious bovine rhinotracheitis virus, bovine viral diarrhea, or parainfluenza-3 virus. Average daily gain, daily feed intake, and feed:gain ratio for the 42-day study were not affected by supplemental Agrado ($P > .10$).

Experiment 2. No significant ($P > .10$) effect of dietary treatment on the number of morbid steers, medication costs, the number of calves becoming sick a second time, or on the day that first illness occurred were detected (Table 3).

There were no significant ($P > .10$) effects of supplementing Agrado on average daily gain, feed intake, or feed:gain ratio for the 41-day trial, although added Agrado decreased the feed:gain ratio from day 0 to 28 ($P < .04$). Numerically, steers supplemented with Agrado had a greater ($P = .13$) average daily gain during the first 28 days of the trial. Steers supplemented with Agrado also had numerically lower ($P = .19$) feed:gain ratios than controls during the 41-day study.

Discussion

Ethoxyquin is permitted by the FDA to be included as a preservative in feeds at 150 ppm. Whether Agrado acts directly as an antioxidant in the digestive tract, or in feeds to enhance the availability of other antioxidants is not known. In poultry, ethoxyquin lowers the selenium requirement of vitamin E deficient chicks (Combs, 1978), presumably acting as a metabolic antioxidant.

Supplementation of antioxidant nutrients in receiving rations for calves often has proven to be beneficial. In addition to research conducted with vitamin E, supplementing higher than levels recommended by the NRC (1996) of zinc (Hutcheson, 1985; Chirase et al., 1991) has improved growth performance and immune function of receiving cattle. Deficiencies of selenium (Arthur and Boyne, 1985; Reffett et al., 1988) and copper (Boyne and Arthur, 1981; Nockels, 1993), known to participate in antioxidant enzymes, negatively impact immunocompetence.

Our results with supplemental Agrado differed between our two experiments, perhaps due to differences in exposure to stress. The heifers used in Experiment 1 were more "at risk," being lightweight and obtained from sale barns in the fall. Historically, disease incidence of receiving cattle is higher in the fall and mean incidence of morbidity was greater in Experiment 1 (78%) than Experiment 2 (58%). In Experiment 1, supplemental Agrado significantly reduced the incidence of morbidity by 12% suggesting a positive effect of the antioxidant on immune function. Ethoxyquin previously has eliminated the suppressive effect of vitamin E deficiency on lymphocyte function in dogs (Langweiler et al., 1983). In contrast, Bailey et al. (1996) detected no response to ethoxyquin supplementation in antibody response to Newcastle disease virus by cockerels. In Experiment 2, no significant effect ($P = .38$) of Agrado on morbidity was detected.

No significant effect on calf performance was detected in Experiment 1, but feed:gain ratio was improved during the first 28 days of Experiment 2. As expected, the steers used in Experiment 2 ate more feed and grew faster than the heifers used in Experiment 1. The steers supplemented with Agrado tended to gain more weight during the first 28 days of the study, and have a lower feed:gain ratio for the 41-day feeding period. Research at Oklahoma State University has shown that cattle supplemented with Agrado for the final 28 days on feed had slightly greater average daily gain and improved feed:gain ratio (F.N. Owens, personal communication).

Using prices available at the conclusion of both experiments the calves supplemented with Agrado had higher value than the unsupplemented calves ($4.19/calf in Experiment 1 and $3.20/calf in Experiment 2).

Implications

Supplementation with Agrado improved the health of receiving cattle in one of two experiments. Dietary antioxidants are important components of receiving rations. Supplementing Agrado, an antioxidant, is an economical way to increase the supply of dietary antioxidants for calves.

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Table 1. Diet used in Experiments 1 and 2 (as fed basis).

Ingredient	%
Corn, cracked	53.42
Cottonseed hulls	30.0
Soybean meal	11.0
Molasses, blend of cane and beet	4.1
Dicalcium phosphate	0.4
Limestone	0.85
Salt, white	0.15
Vitamin premix[1]	0.075
Trace mineral premix[2]	+
Bovatec[3]	+
Agrado[4]	- / +

[1]Vitamin premix provided 2,000 IU vitamin A, 400 IU vitamin D, and 5 IU vitamin E/lb of diet.
[2]Trace mineral premix added 26 ppm zinc and 0.1 ppm selenium.
[3]Added to provide 33.6 ppm lasalocid.
[4]Powdered form assayed at 58% (Experiment 1) and 60% (Experiment 2) purity added to provide 0 or 150 ppm of diet DM.

Table 2. Effect of Agrado on growth performance and morbidity (Experiment 1).

	Control	Agrado[1]	SE	P =
Initial weight, lb	454	454	0.208	0.47
Final weight, lb	535	536	4.860	0.92
Average daily gain, lb				
Day 1 to 14	0.22	0.32	0.174	0.69
Day 1 to 26	1.87	1.91	0.083	0.75
Day 1 to 42	1.93	1.96	0.113	0.89
Daily feed intake, lb				
Day 1 to 14	8.07	8.16	0.053	0.25
Day 1 to 26	11.16	11.15	0.209	0.98
Day 1 to 42	13.65	13.62	0.302	0.93
Feed:gain				
Day 1 to 14	-2.63	12.32	19.470	0.60
Day 1 to 26	6.44	6.20	0.214	0.46
Day 1 to 42	7.32	7.04	0.335	0.58
Morbidity, %	83.30	72.90	3.100	0.02
Medicine cost, $/calf	9.49	6.32	0.867	0.05

[1]Agrado supplemented at 150 ppm of diet DM.

Table 3. Effect of Agrado on growth performance and morbidity (Experiment 2).

	Control	Agrado[1]	SE	P =
Initial weight, lb	525	525	0.210	0.64
Final weight, lb	650	655	4.910	0.54
Average daily gain, lb				
Day 1 to 7	2.60	2.84	0.496	0.75
Day 1 to 14	2.65	2.62	0.225	0.94
Day 1 to 28	3.31	3.63	0.133	0.13
Day 1 to 41	3.07	3.17	0.120	0.56
Daily feed intake, lb				
Day 1 to 7	12.90	12.14	0.253	0.07
Day 1 to 14	14.57	13.81	0.368	0.18
Day 1 to 28	17.33	16.95	0.449	0.57
Day 1 to 41	19.35	18.88	0.380	0.41
Feed:gain				
Day 1 to 7	12.66	4.83	5.650	0.36
Day 1 to14	5.57	5.66	0.369	0.87
Day 1 to 28	5.28	4.69	0.163	0.04
Day 1 to 41	6.34	6.01	0.166	0.19
Morbidity, %	53.00	63.00	7.200	0.38
Medication cost, $/calf	8.17	8.84	1.160	0.69

[1]Agrado supplemented at 150 ppm of diet DM.

Production of Stocker Cattle Supplemented with Defatted Rice Bran while Grazing Bermudagrass Pasture

L.B. Daniels[1], Ken P. Coffey[1], Kenneth F. Harrison[2], Don Hubbell, III[2], and Zelpha B. Johnson[1]

Story in Brief

Forty-two commercial crossbred steers, averaging 540 lb of body weight were supplemented with either zero or three pounds per head per day of defatted rice bran while grazing bermudagrass pasture from July 21 until September 16. Steers supplemented with rice bran grew significantly faster than those not supplemented. It took approximately 8 lbs rice bran to produce a pound of gain at a cost of approximately 40 cents per pound of gain.

Introduction

Arkansas is the number one producer of rice in the United States and therefore a large supply of rice bran is available as a by-product of the rice milling industry. Rice bran has excellent nutritive value for ruminant animals. The objective of this study was to evaluate the value of defatted rice bran as a feed supplement for stocker cattle while grazing bermudagrass pastures.

Experimental Procedures

Forty-two commercial crossbred steers, averaging 540 lb of body weight, were assigned to two treatment groups and were supplemented daily with either zero or three pounds of rice bran per head while grazing bermudagrass pasture. Steers were rotated to a different bermudagrass pasture every 28 days. All steers were implanted with Ralgro®, and dewormed with ivermectin at the beginning of the study. The trial began on July 21 and continued until September 16. All steers were weighed every 14 days, using both a 12-hour shrunk weight and a full weight. Treatments were replicated three times with seven steers per replication. The data was analyzed by ANOVA procedures of SAS (1988).

Results and Discussion

The average daily gain and total gain for the steers are given in Table 1. No statistical differences (P>.05) were observed between treatments. Steers supplemented with three pounds of defatted rice bran per head per day grew faster (P<.05), averaging 1.66 lb gain per head per day as compared to 1.29 lb gain per head per day when not supplemented with rice bran. It took approximately 8 lb of rice bran to produce one pound of gain. If defatted rice bran had a value of $100 per ton, it would cost 40 cents per pound of gain. Therefore, defatted rice bran appears to be an excellent and economical supplement for stocker cattle grazing bermudagrass pasture in Arkansas.

Reference

SAS, 1988. SAS Inst., Inc., Cary, North Carolina.

Table 1. Average daily gain and total gain of steers supplemented with rice bran while grazing bermudagrass pastures.

	0 lb Rice bran	3 lb Rice bran/head/day
Initial weight, lb	541	540
Days on study	56	56
ADG, lb	1.29	1.66
Total gain, lb	72	93
Lbs defatted rice bran/lb gain	-	8.11
Cost of lb gain from defatted rice bran	-	$0.40

[1]Department of Animal Science, Fayetteville.
[2]Livestock and Forestry Branch Experiment Station, Batesville.

Developing Beef Heifers During the Winter Months with Stockpiled Burmudagrass Forage

L.B. Daniels[1], A.H. Brown, Jr.[1], K.F. Harrison[2], D. Hubbell, III[2] and Z.B. Johnson[1]

Story in Brief

Forty-eight heifers averaging 450 lb, grazed either bermudagrass, endophyte-free fescue or endophyte-infected fescue that had been allowed to accumulate during late summer and fall. Grazing began on December 10, 1996 and continued through March 12, 1997. All heifers were then allowed to graze soft-red winter wheat forage until April 15, 1997. Heifers grazing endophyte-infected fescue grew slower when grazing wheat forage than those grazing endophyte-free fescue or bermudagrass.

Introduction

Bermudagrass is the predominant warm season forage grass produced in Arkansas. If moisture is available, it makes rapid growth during the late summer and early fall and usually considerable tonnage of forage remains after frost. This residue of bermudagrass is approximately 8 to 10% crude protein and over 50% TDN. Most replacement heifers in Arkansas beef herds are developed by Arkansas beef producers. These heifers are traditionally fed fescue or bermudagrass hay plus a small amount of grain while grazing fescue pastures. Fescue has traditionally been stockpiled for overwintering the cow herd, and there is some interest in stockpiled bermudagrass for overwintering cow herds. The objective of this study was to evaluate stockpiled bermudagrass as a forage for developing beef heifers during the winter months.

Experimental Procedures

Sixteen acres each of permanent bermudagrass, endophyte-free and endophyte-infected tall fescue pastures were allowed to grow and the forage to accumulate during the late summer and fall of 1996. The pastures were fertilized according to soil test recommendations. Endophyte-infected fescue contained over 75% infection of the toxic endophyte. Thirty-two Angus heifers and 12 Charolais heifers, averaging 450 pounds of body weight, were randomly assigned to one of three treatment groups (1) stockpiled bermudagrass, (2) stockpiled endophyte-free fescue, or (3) stockpiled endophyte-infected fescue. All heifers were weighed after fasting for 12 hours and placed in their respective pasture on December 10, 1996 and were allowed to graze that pasture until March 12, 1997. They were removed from their respective pastures and allowed to graze soft-red winter wheat forage until April 15, 1997. Each treatment was replicated twice with six Angus and two Charolais per replication. Each pasture was divided by electrical fence into eight-acre pastures. Heifers had free access to water and a trace mineral mix. No other supplement was provided. All heifers were bred in late May and early June, 1997 (Angus at 550 to 600 lb and Charolais at 750 to 800 lb) and calving percentage recorded. Bred heifers grazed bermudagrass pastures during the summer and fescue until calving in spring, 1998. Data were analyzed by ANOVA procedures of SAS (1998).

Results and Discussion

The ADG and total gain (TG) of heifers grazing their respective stockpiled forage are given in Table 1. There were no statistical differences ($P > .05$) in ADG or TG of heifers due to forage grazed. However, heifers grazing stockpiled burmudagrass grew similarly (ADG = 1.2 lb) to those grazing non-infected fescue (ADG = 1.5 lb) or those grazing endophyte-infected fescue (ADG = 1.4 lb) or bermudagrass (ADG = 1.2 lb). These data suggest that satisfactory growth can be obtained when replacement heifers grazed stockpiled bermudagrass.

Growth of heifers, which grazed wheat forage following grazing either stockpiled bermudagrass or fescue, is given in Table 2. Heifers grazing stockpiled bermudagrass grew similarly to those grazing endophyte-free fescue and numerically faster than those grazing endophyte-infected fescue.

Percentage of heifers calving is in Table 3. A higher percentage of Angus calved than did the Charolais (87.5 vs. 45.0).

These data suggest that bermudagrass can be stockpiled as forage for growing beef heifers during the winter months.

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SAS. 1998. SAS Inst., Inc., Cary, North Carolina.

[1]Department of Animal Science, Fayetteville
[2]Livestock and Forestry Branch Experiment Station, Batesville

Table 1. Average daily gain (ADG) and total gain (TG) of heifers which grazed stockpiled bermudagrass, endophyte free (-) fescue or endophyte infected (+) fescue.

Item	Bermudagrass	(-) fescue	(+) fescue
Initial wt, lb	458	453	454
Days grazed	92	92	92
ADG, lb	1.2	1.5	1.4
TG, lb	114	141	129

Table 2. Growth of heifers while grazing wheat forage following grazing of stockpiled bermudagrass or fescue.

Item	Bermudagrass wheat	(-) fescue wheat	(+) fescue wheat
Initial wt, lb	573	582	583
Days grazed	34	34	34
ADG, lb	2.5	2.6	2.1
TG, lb	85	88	70
Final wt, lb	658	670	653

Table 3. Percentage of heifers calving that had grazed stockpiled bermudagrass and fescue.

Breed	BG	(+) F	(-) F	Av.
Angus	100	73	90	87
Charolais	0	75	60	45
Avg	73	73	80	75

Use of Soft-Red Winter Wheat Forage for Stocker Cattle Production During the Fall and Winter[1]

L.B. Daniels[2], K.F. Harrison[3], D. Hubbell, III[3], A.H. Brown, Jr.[2], E.B. Kegley[2], K.P. Coffey[2], W. Coblentz[2], Z.B. Johnson[2], and R. Bacon[4]

Story in Brief

Two cultivars of soft-red winter wheat (*Triticum aestivum* L.) were seeded at 120 lb/A (acre) on September 10-11, 1996 and 1997. One-half of each cultivar received 50 lb nitrogen(N)/A above recommended soil analysis. Sixty Angus x Brangus and 60 commercial crossbred steers, averaging 500 lb body weight, were assigned to their respective wheat forage at a stocking density of 500 and 750 lb beef/A on October 23 and 29 for 1996 and 1997, and removed on February 17 and 4 in 1997 and 1998, respectively. ADG, total gain (TG) and gain per acre (G/A) were greater ($P < .01$) for steers that grazed Jaypee forage in 1997-98, but did not differ during 1996-97. Steers grazing pastures with added N produced more ($P < .05$) G/A than those grazing pastures without additional N in 1996-97. No differences occurred in G/A due to added N during 1997-98 or for the combined years. Steers stocked at 500 lb beef/A had ADG and TG greater ($P<.01$) than those steers stocked at 750 lb beef/A. However, steers that were stocked at 750 lb beef/A produced more ($P < .01$) G/A than steers that were stocked at 500 lb beef/A.

Introduction

Arkansas leads the nation in the production of soft-red winter wheat, producing over 45,000,000 bushels annually from approximately one million acres (Klugh and Abbe, 1995). With the phase-out of the Federal Crop Deficiency Payment Program, wheat farmers must have a secondary source of income from their land. The production of stocker cattle from grazing hard-red winter wheat forage in the southern plains is a unique and economical renewable resource. Income is derived from both grain and the increased value that is added as weight gain to growing cattle that grazed winter wheat forage and has been a practice for many years in the southern plains (Horn et al., 1994).

Over 25% of the nation's beef cows are located in this region (Taylor, 1994). Approximately one million beef cows, which produce nearly 875,000 calves annually, are located in Arkansas (Klugh and Abbe, 1995). Most of these calves are sold at weaning during the fall to cattlemen in the southern plains and other western states. Considerable interest in retaining ownership of calves is developing by producers in the southern region. Therefore, it is the objective of this study to evaluate soft-red winter wheat forage as pasture for stocker cattle during the fall and winter.

Experimental Procedures

Twenty-four two-acre pastures, having a Perridge silt loam soil, were sprayed three times with 1/3 gallon per spraying of Roundup® per acre during the summer of 1996 and then tilled to prepare a seedbed. The pastures were seeded on September 10-11 during 1996 and 1997 with either 'Hickory' or 'Jaypee' cultivars of soft-red winter wheat (*Triticum aestivum* L.) at a seeding rate of 120 lb seed/A. Individual soil test analyses were done on each pasture each year, and the pastures were fertilized according to the soil test analysis for wheat grain production. One half of the pastures of each cultivar was top-dressed with urea at seedling emergence to supply 50 lb additional nitrogen (N)/A. Forage samples were taken at 10 locations in each pasture by clipping every 28 days and frozen. They were analyzed for CP, neutral detergent fiber (NDF), acid detergent fiber (ADF), and *in vitro* dry matter digestibility (IVOMD).

Sixty crossbred Angus x Brangus and 60 crossbred commercial steers, averaging 500 lb BW, were preconditioned and used as experimental animals in 1996-97 and 1997-98, respectively. Steers were assigned to treatment groups in a 2 x 2 x 2 factorial arrangement as follows:

[1] Research was supported in part by the Arkansas Wheat Board.
[2] Department of Animal Science, Fayetteville.
[3] Livestock and Forestry Branch Experiment Station, Batesville.
[4] Department of Crop, Soil, and Environmental Sciences, Fayetteville.

1) Hickory cultivar - 0 lb added N/A - 500 lb beef/A
2) Hickory cultivar - 0 lb added N/A - 750 lb beef/A
3) Hickory cultivar - 50 lb added N/A - 500 lb beef/A
4) Hickory cultivar - 50 lb added N/A - 750 lb beef/A
5) Jaypee cultivar - 0 added N/A - 500 lb beef/A
6) Jaypee cultivar - 0 added N/A - 750 lb beef/A
7) Jaypee cultivar - 50 lb added N/A - 500 lb beef/A
8) Jaypee cultivar - 50 lb added N/A - 750 lb beef/A

Treatments were replicated three times. Steers were weighed and blood taken via jugular puncture when steers were placed on their respective wheat forage pasture and at 14-day intervals. Feed and water were removed from the steers 12 hours before each weighing. Two pounds of corn (*Zea mays* L.) were fed to each steer daily plus bermudagrass (*Cynodon dactylon* [L.] Pers) hay as needed. Steers also had free access to a trace mineral-salt mixture, which contained 200 mg of monensin per pound. The steers were assigned to their respective wheat forage on October 23 and 29 during 1996 and 1997, and allowed to continuously graze until removal on February 17 and 4 during 1997 and 1998, respectively. In 1997, the steers were fed 121 days in a commercial feedlot following wheat pasture, and carcass data were taken at slaughter. During 1997-98 total gain (TG) and gain/acre (G/A) were adjusted to 117 days to compare to 1996-97 data, which was based on a 117-day growing period.

Data for each year were analyzed by ANOVA procedures of SAS (1988) with a 2 x 2 x 2 factorial arrangement of treatments. Data for combined years were analyzed using PROC MIXED of SAS (Littell et al., 1996) where pasture was a random effect. Sampling data was a repeated effect for serum magnesium (Mg) data and year was a repeated effect for gain data. All interactions were examined.

Results and Discussion

Percentage of CP, (IVDMD, NDF and ADF of soft-red winter wheat forage as affected by cultivar, added N, stocking density and month of the year are given in Table 1. Crude protein was higher ($P<.05$) and ADF lower ($P < .01$) in the cultivar Hickory than in the cultivar Jaypee. Added N also increased ($P < .05$) the CP in the wheat forage. Stocking density decreased ($P < .01$) the ADF in the wheat forage. Forage quality decreased ($P < .01$) from October to February. There were no differences in IVDMD or NDF due to treatments. Even though there were statistical differences in forage quality, all of the wheat forage was of exceptional quality and would support rapid growth of cattle. This is evident since the lowest CP was 19.6% and IVODMD was 92.7% or above.

Serum Mg concentrations of steers that grazed soft-red winter wheat forage are given in Table 2. Serum Mg concentrations were lower ($P < .01$) in steers during 1997-98 than in those calves during 1996-97. A cultivar x added N x stocking density interaction ($P < .01$) occurred during November and December and January ($P < .05$). However, even though there were statistical differences, all steers serum Mg concentrations were within the normal physiological range (1.4 - 3.3 mg/dl) for steers of their body weight (Clarenburg, 1992; Neumann and Lusby, 1986).

The ADG, TG, 117-day adjusted total gain (117 TG), G/A and 117-day adjusted gain per acre (117 G/A) for steers grazing soft-red winter wheat forage during the fall and winter of 1996-97 and 1997-98 are given in Table 3. Average daily gains were greater ($P < .01$) for those steers grazing the cultivar, Jaypee, during 1997-98 and for combined years than in those steers that grazed the cultivar, Hickory. However, no differences occurred in ADG of steers due to cultivar during 1996-97. The cultivar effect on ADG may have been due to more forage production by Jaypee than Hickory during 1997-98. Jaypee lacks cold and wet tolerance and produces much more forage during mild temperatures, which occurred during 1997-98. In 1996-97, in January and February, 12 days during the study the wheat forage was either frozen, or covered with ice or snow, whereas during 1997-98, there were no days the forage was frozen or covered with snow or ice. Mean high and low temperatures and rainfall by months are given in Table 4 for years 1996-97 and 1997-98. Horn et al. (1994) reported differences in ADG of steers grazing different cultivars of hard-red winter wheat. Similar cultivar differences have been reported by Gribble and Krenzer (1994).

There were no differences in ADG due to added N. Gribble and Krenzer (1994) reported that for every 100 lb livestock gain when cattle grazed hard-red winter wheat forage, 30 lb/A of actual N was needed. Applying this to soft-red winter wheat forage, approximately 100 lb N/A would have been required in the present study. Soil N of the pastures in this study averaged 146 lb N/A when no additional N was added and 175 lb N/A when 50 lb N/A were added.

Average daily gain was greater ($P < .01$) for steers grazing soft-red winter wheat forage at a stocking density of 500 lb beef/A than for those grazing wheat pastures having a stocking density of 750 lb beef/A. This difference in ADG was probably due to forage availability. Horn et al. (1994) reported that ADG of steers decreases as stocking density increases when steers graze hard-red winter wheat forage.

Steers grazing Jaypee gained more ($P < .01$) weight than those steers grazing Hickory during 1997-98 and combined years. However, there were no differences in TG due to cultivar during 1996-97. No differences in TG were observed from added N. Steers grazing wheat pastures having a stocking density of 500 lb beef/A had greater ($P < .01$) TG than those steers grazing wheat pastures having a stocking density of 750 lb beef/A.

When TG was adjusted to a 117-day grazing period to put years 1996-97 and 1997-98 on equal basis, steers grazing Jaypee had a greater ($P < .01$) 117-day adjusted gain than those steers grazing Hickory. Steers grazing wheat pastures at a stocking density of 500 lb beef/A had a greater ($P < .01$) 117-day adjusted gain than those steers grazing wheat pastures having a stocking density of 750 lb beef/A.

Total gain in this study is greater than that reported by Horn et al. (1994) for hard-red winter wheat. However, stock-

ing density in the present study was two to three times (500 to 750 lb beef/A compared to 250 lb beef/A for hard-red winter wheat) that used by Horn et al. (1994).

Steers that grazed Jaypee produced more ($P < .05$) G/A during 1997-98 and for years combined than those which grazed Hickory. No differences occurred in G/A during 1996-97 because of cultivar. Steers grazing wheat pastures at a stocking density of 750 lb beef/A produced more ($P < .01$) G/A than those steers grazing wheat pastures having a stocking density of 500 lb beef/A. Horn (1994) observed that G/A increased as stocking density increased when steers grazed hard-red winter wheat forage, but G/A in his study was much less than that reported in the present study because stocking density was much lower (250 lb beef/A) than the 500 and 750 lb beef/A used in the present study.

When G/A for 1997-98 was adjusted to a 117-day grazing period, steers that grazed Jaypee produced more ($P < .01$) 117 G/A than those steers that grazed Hickory. Steers grazing wheat pastures having a stocking density of 750 lb beef/A produced more ($P<.01$) 117 G/A than did those grazing pastures having a stocking density of 500 lb beef/A.

Feedlot performance and carcass data of steers that grazed soft-red winter wheat from October 23 to February 17 are given in Table 5. Steers gained 3.65 lb/day over a 121-day feeding period on 6.1 lb dry feed at a cost of $2.16/head/day. Seventy three percent of the steers graded Choice while 27% graded Select. Dressing percentage averaged 62.4%.

In conclusion, soft-red winter wheat, when planted in early September, produces an ample supply of exceptional quality forage that will support rapid growth of stocker cattle during the fall and winter with minimal supplementation. Differences exist in the quality of forage of different cultivars.

Average daily gains of 2.4 lb for steers grazing soft-red winter wheat forage are superior to the 2.0 to 2.3 lb ADG of steers grazing hard-red winter wheat (Horn, 1994; Horn et al., 1994). Total gain of steers differed as a result of cultivar. Jaypee, a cultivar that prefers mild weather, was superior to Hickory during 1997-98, which was an extremely mild fall and winter. Total gain also was influenced by stocking density (the lower the stocking density, the greater the total gain per steer). However, G/A was greater at the highest stocking density. Both TG and G/A of steers grazing soft-red winter wheat were superior to those reported (Horn, 1994; Horn et al., 1994) for steers grazing hard-red winter wheat.

Stocking density may be doubled or tripled for steers grazing soft-red winter wheat compared to hard-red winter wheat. Steers were stocked at a density of 500 and 750 lb beef/A in this study compared to 250 lb beef/A used to graze hard-red winter wheat in the southern plains (Horn et al., 1994). Therefore, production of stocker cattle on soft-red winter wheat forage in the Southern region has excellent potential. Grazing of cattle can begin in October and be terminated by March 1, producing a steer large enough to be fed without reducing wheat grain yield (Krenzer, et al., 1994).

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Table 1. Percentage of crude protein (CP), *in vitro* dry matter digestibility (IVDMD), neutral detergent fiber (NDF) and acid detergent fiber (ADF) of soft-red winter wheat.

Month	Treatment	CP	IVDMD	NDF	ADF
		----------%----------			
October	Hickory	29.8	92.8	43.4	18.4
	Jaypee	30.3	92.8	42.8	18.8
November	Hickory	26.4	94.0	42.8	19.9
	Jaypee	24.7	94.2	43.1	22.2
December	Hickory	23.8	96.5	43.3	21.2
	Jaypee	23.0	94.8	43.3	22.2
January	Hickory	21.7	93.9	43.2	25.7
	Jaypee	20.2	94.0	44.2	27.7
February	Hickory	21.3	94.8	52.1	30.2
	Jaypee	19.7	95.0	52.6	31.9
October	0 added N	30.2	92.9	43.1	18.7
	50 lb added N/A	29.9	92.8	43.1	18.7
November	0 added N	24.8	94.1	43.2	21.5
	50 lb added N/A	26.3	93.9	42.7	20.6
December	0 added N	22.7	96.2	44.1	21.5
	50 lb added N/A	24.1	96.3	43.4	21.7
January	0 added N	20.1	94.1	44.3	27.7
	50 lb added N/A	21.2	93.8	43.0	25.7
February	0 added N	19.6	94.4	52.6	31.9
	50 lb added N/A	21.4	94.7	52.0	30.1
October	500 lb beef/A	29.8	92.7	43.3	18.5
	750 lb beef/A	30.4	92.8	42.8	18.6
November	500 lb beef/A	25.6	93.7	43.1	20.5
	750 lb beef/A	25.5	94.3	42.8	18.6
December	500 lb beef/A	23.8	96.3	43.7	26.3
	750 lb beef/A	23.1	96.2	43.7	22.7
January	500 lb beef/A	20.8	93.9	43.7	26.3
	750 lb beef/A	20.5	94.1	43.6	25.7
February	500 lb beef/A	21.6	94.7	52.5	31.7
	750 lb beef/A	19.5	95.1	52.3	30.1

Table 2. Blood serum magnesium (Mg) concentration of steers that grazed soft-red winter wheat forage during fall and winter (mg/dl).

Year	Month	Cultivar		Nitrogen		Stocking density	
		Hickory	Jaypee	0-N	50 lb/A	500 lb/A	750 lb/A
1996-97	October	2.5	2.5	2.5	2.5	2.5	2.6
1997-98		2.1	2.2	2.1	2.2	2.2	2.1
Combined		2.3	2.4	2.3	2.3	2.3	2.4
1996-97	November	2.5	2.5	2.6	2.5	2.5	2.6
1997-98		2.4	2.4	2.4	2.5	2.5	2.4
Combined		2.5	2.5	2.5	2.5	2.5	2.5
1996-97	December	2.4	2.4	2.4	2.4	2.4	2.4
1997-98		2.1	2.1	2.1	2.2	2.1	2.1
Combined		2.3	2.3	2.3	2.3	2.3	2.3
1996-97	January	2.4	2.4	2.4	2.4	2.4	2.4
1997-98		2.0	2.0	2.0	2.0	2.0	2.0
Combined		2.2	2.2	2.2	2.2	2.2	2.2

Table 3. Average daily gain (ADG), total gain (TG), 117-day adjusted total gain (117 TG), gain per acre (G/A) and 117-day adjusted gain per acre (117 G/A) of steers that grazed soft-red winter wheat forage during the fall and winter of 1996-97 and 1997-98.

Treatment	Year	ADG	TG	117 TG	G/A	117 G/A
		----------	----------	lb ----------	----------	----------
Hickory	1	2.35	281.4	281.4	344.5	344.5
	2	2.18	213.5	254.9	263.7	314.6
	C	2.26	247.4	268.1	304.1	329.6
Jaypee	1	2.40	281.0	281.0	345.1	345.1
	2	2.56	251.1	299.9	285.6	370.8
	C	2.48	266.0	290.4	315.4	358.0
0-N	1	2.46	287.7	287.7	337.5	37.5
	2	2.36	231.7	276.7	284.6	339.8
	C	2.41	259.7	282.2	311.0	338.6
50 lb N/A	1	2.31	268.8	268.8	351.9	351.9
	2	2.38	232.9	273.1	290.4	345.8
	C	2.34	250.8	271.0	321.1	348.8
500 lb beef/A	1	2.57	300.9	300.9	300.9	300.9
	2	2.50	245.7	293.2	245.7	293.1
	C	2.53	273.2	297.0	273.3	297.0
750 lb beef/A	1	2.18	255.6	255.6	384.8	384.8
	2	2.24	219.1	261.6	328.7	329.4
	C	2.21	237.3	258.6	356.7	388.6

Table 4. Average high and low temperatures and rainfall during October through February, 1996-97 and 1997-98 (°F).

Month	1996-97			1997-98		
	High	Low	Rainfall (in)	High	Low	Rainfall (in)
October	75	49	2.73	75	50	3.48
November	54	37	12.61	57	49	1.99
December	54	34	2.74	50	32	3.46
January	51	28	1.72	53	35	4.61
February	56	36	5.36	57	37	3.38

Table 5. Feedlot performance and carcass data of steers that had grazed soft-red winter wheat forage.

Item	Amount
Days of feed	121
Entering weight, lb	746
Final weight, lb	1,118
ADG, lb	3.65
Dry feed/lb gain	6.10
Cost/head/day	$2.16
% Choice	73
% Select	27
Ribeye area, in^2	12.32
Yield grade	3.25
Dressing percentage	62.4
Hot carcass weight, lb	741.0
Backfat thickness, in	0.55

Evaluation of Pattern of Gain Using Dry-Lot or Wheat-Ryegrass Pasture Programs in Developing Heifers for Breeding

Paul Beck[1] , Stacey Gunter[1], Mike Phillips[1], and David Kreider[2]

Story in Brief

Seventy-five heifers were allocated to four treatments to determine the effect of winter diet (limit-fed concentrate diets vs. grazing winter annuals) and pattern of gain (moderate growth vs slow growth followed by fast growth) on reproductive performance. Treatments included: (MODERATE) limit-fed heifers in dry-lot to gain moderately (1.5 lb/day) from November 24 until breeding; limit-fed heifers in dry-lot to gain slowly (.5 lb/day) from November 11 to February 4 then gain rapidly (approximately 2.0 lb/day) from February 4 until breeding to weights similar at breeding to MODERATE (SLOW/FAST); limit-fed heifers to gain .50 lb/day to February 4, then placed on bermudagrass pastures interseeded with wheat and Marshall ryegrass (WRG) until breeding (SLOW/WRG); or full season grazing of interseeded WRG pasture (GRAZED). MODERATE heifers weighed more than other treatments on February 4, but weights were not different by breeding. GRAZED and SLOW/WRG heifers weighed more at the end of breeding than MODERATE or SLOW/FAST possibly due to effect of previous diet on grazing performance. MODERATE heifers calved earlier than other treatments, which can partly be explained by the higher proportion of heifers puberal than SLOW/FAST and lower serum urea nitrogen levels than SLOW/WRG and GRAZED heifers early in the breeding season.

Introduction

To optimize production, heifers must be bred at 15 months of age to calve as 2-year-olds. Heifers that calve early in the calving season tend to calve early in subsequent calving seasons (Short and Bellows, 1971). Clanton et al. (1983) found that age of puberty was not affected by differing rates of growth by heifers consuming the same diets, as long as their body weights (BW) were similar at the start of the breeding season. In southern Arkansas, the fall and early winter are periods of limited forage availability and BW gains by grazing heifers will be too low to reach puberty by breeding season. Cool season annuals such as wheat and annual ryegrass are high in quality and can support high performing cattle through the winter if adequate forage allowance is maintained through low stocking rates. The two solutions to these problems are 1) decrease stocking rates to increase forage availability or 2) feed large amounts of supplemental feed. In an effort to save feed and decrease land area required for heifer-development enterprises, wheat-ryegrass pasture (WRG) and limit feeding in dry-lot were used to compare the effects of diet and pattern of gain in the development of heifers for breeding.

Materials and Methods

On November 17, 1998, 75 spring-born Angus and Brangus sired heifers (507 ± 50 lb) were allotted by breed and BW to one of four treatments. Treatments were: 1) 19 heifers were limit-fed in dry-lot to gain moderately (1.5 lb/day) from November 24 until breeding (MODERATE), 2) 18 heifers were limit-fed in dry-lot to gain slowly (.5 lb/day) from November 11 to February 4 then gain rapidly (approximately 2.0 lb/day) from February 4 until breeding to BW similar at breeding to MODERATE (SLOW/FAST), 3) 20 heifers were limit-fed to gain .5 lb/day to February 4, then placed on bermudagrass pastures interseeded with WRG until breeding (SLOW/WRG), or 4) 18 heifers grazed interseeded WRG pasture from November 24 until breeding adjusting forage allowance to allow BW gains of approximately 1.5 lb/day (GRAZED). Pasture size was altered during the trial to change forage allowance in an attempt to keep BW gains within desired range. Supplemental hay (free-choice) and corn gluten feed (2 lb/animal/day) was fed to GRAZED heifers, during a four-week period of limited forage availability between mid-December and mid-January, low consumption of hay was observed.

[1] Southwest Research & Extension Center, Hope.
[2] Department of Animal Science, Fayetteville.

Diets for limit-fed heifers are shown in Table 1. Heifers on limit-fed treatments were fed once a day at a level designed to meet energy requirements (Net Energy) for the desired level of performance.

Heifers were weighed and bled at weekly intervals, from March 3 through June 12. Blood was analyzed for progesterone to determine the onset of puberty (> 1 ng progesterone/ml of serum for two consecutive weeks) and serum urea nitrogen (SUN). Estrus was synchronized following the two prostaglandin injection procedure (American Breeder Service A.I. Management Manual, 1986). Two shots of Lutalyse (Pharmacia &Upjohn, Kalamazoo, Michigan) were administered on March 31 and April 11 to synchronized estrus. On April 13, 13 heifers were artificially inseminated after they were observed to be in standing estrus. The remainder were artificially inseminated by timed insemination (76 hours after second injection) on April 14. Semen from a Hereford bull was used in the A.I. program, and Angus and Brangus bulls were used as clean-up bulls. On April 21, limit-fed heifers were removed from dry-lot and placed on a bermudagrass pasture and heifers grazing WRG were placed on a WRG pasture. Two bulls per group were then turned in for a 56-day breeding season on April 21 (ending June 15); the bulls were rotated between groups at weekly intervals. On May 10, when bermudagrass was the predominant grass species in both pastures, heifers were combined on a single pasture for the remaining breeding season, and one bull was removed (leaving three bulls to service heifers).

At calving, date and sire breed of the calf was recorded for 50 heifers calved out at the SWREC facilities for determination of conception date. If the sire was determined to be Hereford actual insemination date was used as the conception date. If the sire was determined to be Angus or Brangus then conception date was determined by subtracting 283 days from calving date.

Data were analyzed as a completely randomized design. Heifer BW, ADG SUN, and reproductive performance were analyzed by analysis of variance, using replicate within treatment as the error term. In the presence of a significant treatment effect ($P < .10$), LS means were separated using predicted differences.

Results and Discussion

Performance of the heifers is shown in Table 2. Until February 4, heifers in MODERATE had higher daily gain than heifers in other treatments (1.51, .72, .77, and .85 lb/day for treatments 1 to 4, respectively, $P < .05$). From February 4 to April 8, MODERATE heifers had lower daily gain than heifers in other treatments (.81, 1.66, 1.78, and 1.70 lb/day; $P < .05$). On April 8, BW did not differ (673, 661, 670, and 678 lb; $P = .46$). But by the end of breeding, GRAZED heifers (723 lb) were heavier ($P < .05$) than MODERATE (682 lb) and SLOW/FAST (668 lb). At the end of breeding, BCS was higher ($P < .05$) for GRAZED (6.3) than MODERATE (5.8) and SLOW/FAST (5.8); and SLOW/WRG (6.1) tended ($P = .16$) to have higher BCS than MODERATE or SLOW/FAST. The difference in BW and BCS indicates that the prior diet (wheat vs. dry-lot) of the heifers affected the ability of the heifers to grow and gain condition while on grass during breeding.

From November 24 to February 3, MODERATE heifers were fed an average of 13.9 lb of feed daily, compared to 10.4 and 10.3 for SLOW/FAST and SLOW/WRG. From February 4 to April 8, MODERATE heifers were fed an average of 15.4 lb of feed daily and SLOW/FAST heifers were fed 16.9. Overall, the MODERATE heifers were fed an average of 14.6 lb per day and SLOW/FAST were fed 13.4. Over the 135-day feeding period SLOW/FAST heifers were fed 162 lb per head less than MODERATE and SLOW/WRG were fed 1,217 lb per head less than MODERATE, to reach similar weights. The GRAZED heifers performed comparably with virtually no supplemental feed.

Reproductive performance of the heifers is shown in Table 3. Numbers of heifers reaching puberty by April 8 did not differ ($P = .79$) among treatments. More GRAZED heifers ($P < .05$) were cycling by the end of breeding (June 12) compared to other treatments. Weight and age at puberty were not significantly affected by treatment. The higher proportion of GRAZED heifers cycling at the end of breeding and their tendency to have higher BCS and BW after breeding, supports the theory that grazing performance during breeding was affected by treatment diet.

Pregnancy was determined by rectal palpation on October 21, 1998. MODERATE tended ($P = .16$) to have higher conception than SLOW/WRG and GRAZED. MODERATE heifers had the earliest average calving date while GRAZED heifers had the latest, indicating MODERATE heifers bred earlier in the breeding season. The MODERATE and SLOW/FAST treatments had numerically higher percentage of A.I. sired calves then either SLOW/WRG or GRAZED. Figure 1 shows the SUN levels in the heifers in February, April before A.I., May before bull turnout, and at the end of the breeding season in June. GRAZED heifers had higher ($P < .05$) SUN levels than MODERATE and SLOW/FAST in February, April and May. The SLOW/WRG heifers had higher ($P = .06$) levels in May and tended ($P = .15$) to have higher SUN levels in April. Serum urea nitrogen levels increased in all heifers in June, presumably due to the onset of high quality growth of bermudagrass and other warm season grasses. High levels of SUN have been shown to decrease conception, due to an decreased pH in the uterus causing poor fetal survivability in early pregnancy (Elrod et al, 1993), which explains the later breeding and fewer A.I. calves with the SLOW/WRG and GRAZED heifers.

Implications

This trial shows some options available to producers of replacement heifers. Without a major effect on reproductive performance, heifers can be held back or limit fed to gain slowly for a period of time with considerable saving in feed. This can be done during periods of limited forage availability (early fall and winter, or periods of drought). During

periods of low grain/feed prices, limit feeding shows promise as an inexpensive way to develop heifers either until the spring flush of rapid forage growth occurs or up to breeding as compared to more conventional 'dry wintering' type programs. Problems were evident in this trial with breeding heifers while grazing high quality forages, causing delayed breeding and decreased reproductive efficiency.

Literature Cited

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Table 1. Diets fed to limit-fed treatments.

Item	% of DM
Ingredient	
Corn	35.2
Corn gluten feed	35.2
Bermudagrass hay	26.5
Vigortone 46S[a]	1.6
Limestone	1.2
Salt	.39
Copper sulfate	.01
Calculated composition	
Crude protein	13.7
NEm (Mcal/lb)	.76
NEg (Mcal/lb)	.49

[a] Mineral premix composition 21.5 to 25.8% calcium, 4% phosphorus, 5 to 6% salt, 1.3% magnesium, 7% potassium, 190 ppm copper 14.7 ppm selenium, and 650 ppm zinc.

Table 2. Performance of heifers as affected by treatment.

	Treatments				
	MODERATE[a]	SLOW/FAST	SLOW/WRG	GRAZED	*P*- value
Heifer BW, lb					
November 24	512	504	503	511	.91
February 4	622[b]	557[c]	559[c]	572[c]	.01
April 8	673	661	670	678	.46
June 12	682[c]	668[c]	697[bc]	723[b]	.06
ADG, 11/24 to 2/4	1.51[b]	.72[c]	.77[c]	.85[c]	.09
ADG, 2/4 to 4/8	.81[c]	1.67[b]	1.78[b]	1.70[b]	<.01
Body condition score					
November 24	5.4	5.4	5.4	5.5	.39
February 4	6.3[b]	5.5[c]	5.6[c]	6.0[b]	.01
June 12	5.8[c]	5.8[c]	6.1[bc]	6.3[b]	.10
Feed Intake, lb/heifer/day					
11/24 to 2/3	13.9	10.4	10.3	-	
2/4 to 4/8	15.3	16.9	-	-	
11/24 to 4/8	14.6	13.4	5.6	-	

[a] MODERATE limit-fed heifers in dry-lot to gain moderately (1.5 lb/day) from November 24 until breeding.
SLOW/FAST limit-fed heifers in dry-lot to gain slowly (.5 lb/day) from November 11 to February 4 then gain rapidly (approximately 2.0 lb/d) from February 4 until breeding to weights similar at breeding to MODERATE.
SLOW/WRG limit-fed heifers to gain .50 lb/day to February 4, then placed on bermudagrass pastures interseeded with wheat and Marshall ryegrass (WRG) till breeding.
GRAZED full season grazing of interseeded WRG pasture.

[b,c] LS means within rows with different superscripts differ ($P < .05$).

Table 3. Effect of heifer development treatments on reproductive performance

	Treatments				
	MODERATE[a]	SLOW/FAST	SLOW/WRG	GRAZED	*P* - value
Puberty					
March 3	11.1	11.1	0	5.0	.73
April 8	26.6	38.9	20.0	22.5	.79
June 12	83.9[c]	77.8[c]	75.0[c]	100.0[b]	.04
Age at puberty, days	430	418	425	437	.70
Body weight at puberty	690	680	703	707	.48
Pregnancy rate %	87.5	78.5	73.2	68.7	.16
% via A.I.	37.5	28.6	14.3	0.0	.25
Conception date	April 23[b]	May 1[b]	May 5[c]	May 8[c]	.03
Calving date	February 1	February 8	February 12	February 15	.13

[a] MODERATE limit-fed heifers in dry-lot to gain moderately (1.5 lb/day) from November 24 until breeding.
SLOW/FAST limit-fed heifers in dry-lot to gain slowly (.5 lb/day) from November 11 to February 4 then gain rapidly (approximately 2.0 lb/d) from February 4 until breeding to weights similar at breeding to MODERATE.
SLOW/WRG limit-fed heifers to gain .50 lb/day to February 4, then placed on bermudagrass pastures interseeded with wheat and Marshall ryegrass (WRG) till breeding.
GRAZED full season grazing of interseeded WRG pasture.

[bc] LS means in rows with differing superscripts differ (P < .05)

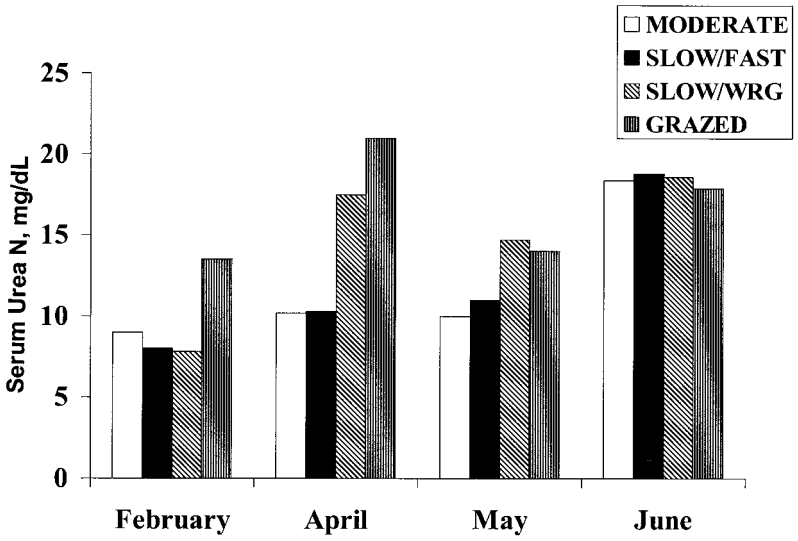

Fig. 1. Effect of heifer development treatments on serum urea nitrogen levels (mg/dL).
MODERATE limit-fed heifers in dry-lot to gain moderately (1.5 lb/day) from November 24 until breeding.
SLOW/FAST limit-fed heifers in dry-lot to gain slowly (.5 lb/day) from November 11 to February 4 then gain rapidly (approximately 2.0 lb/day) from February 4 until breeding to weights similar at breeding to MODERATE.
SLOW/WRG limit-fed heifers to gain .50 lb/day to February 4, then placed on bermudagrass pastures interseeded with wheat and Marshall ryegrass (WRG) till breeding.
GRAZED full season grazing of interseeded WRG pasture.

Diet and Pattern of Gain of Weaned Calves Affects Subsequent Performance on Grass[1]

Paul Beck, Stacey Gunter, Kim Cassida, and Mike Phillips[2]

Story in Brief

During a 102-day period, 154 beef calves (initial weight 400 lb) were fed in dry-lot before winter grazing of fescue or interseeded winter annuals. Treatments included: 1) bermudagrass hay (*ad libitum*) plus 20% CP supplement for ADG of 1.25 lb (HAY); 2) limit feeding in dry-lot for ADG of .5 lb (LOW); 3) limit feeding in dry lot for ADG of 1.25 lb (MODERATE); 4) limit feeding in dry-lot for ADG of 2.0 lb (HIGH). On January 5, the calves were reallocated to either a fescue supplementation trial or placed on winter annuals until the onset of a stocking rate/grazing system trial on February 16. Gains (lb/day) during the dry-lot period were 1.17, .59, 1.14, and 1.60 for HAY, LOW, MODERATE, and HIGH treatments respectively. The HIGH group had the lowest cost of gain/cwt while on dry-lot. Gains during the grazing period were 1.53, 1.85, 1.61, and 1.43 lb/d. Pasture ADG was the highest for the LOW treatment, which compensated for 56% of the weight difference from HIGH treatment calves by the end of the grazing period. Calves in the HAY group gained weight similarly to MODERATE calves on dry-lot, but had reduced pasture performance early in the grazing season, indicating a possible dietary effect on pasture performance. The overall best calculated economic performance was with the HIGH treatment with a gross margin ($/animal) of 114.91 compared to 69.46, 95.57, and 106.41 for HAY, LOW and MODERATE, respectively.

Introduction

In the southeastern United States, millions of calves each year are weaned in the fall; a period of limited availability of quality forage and low demand for calves. If sold at weaning in the fall, calves from spring calving cowherds generally bring seasonally lower prices because of a large supply and low demand. Options for these fall weaned calves include selling in a down market, retaining ownership on dormant forages or hay, or feeding calves a growing diet until quality forages become available or prices improve. If the calves are sold at weaning, it has been estimated that an average profit of $23 per calf can be expected only 9 out of 17 years (Ritchie, 1998). Profitability can be improved by keeping the calf crop through the winter in dry-lot and using high quality forages through the spring and early summer. Limit feeding calves high concentrate diets is an economic alternative to feeding hay. Questions arise as to the effect feeding these diets may have on performance on grass because of factors such as fat deposition, or adverse ruminal effects.

McLean et al. (1990) determined that calves grown on dormant tallgrass prairie or limit-fed high concentrate diets to gain from one to two pounds per day during the winter had subsequently decreased pasture ADG of .33 to .49 lb for each lb increase in ADG during the winter. The purpose of the present experiment is to evaluate grazing performance after limit feeding calves at three rates of gain during the fall/winter growing period; as compared to feeding free choice hay and a concentrate supplement.

Materials and Methods

Two weeks after weaning, 154 weaned beef calves from the University of Arkansas – Southwest Research and Extension Center cow herd were divided into four treatments with two pens per treatment. Treatments included: 1) bermudagrass hay (*ad libitum*) plus 20% CP supplement for ADG of 1.25 lb (HAY); 2) limit feeding in dry-lot for ADG of .5 lb (LOW); 3) limit feeding in dry-lot for ADG of 1.25 lb (MODERATE); 4) limit feeding in dry lot for ADG of 2.0 lb (HIGH). Post-weaning treatments started on September 25, 1998; the calves were weighed full and separated into respective treatments. The HAY calves were left on dry-lot. The limit-fed calves were placed on 2-acre mixed fescue/bermudagrass pastures and fed step-up rations until the desired feed level was attained. Pasture area was then decreased to remove available forage. In this way pasture was used as roughage in the step-up rations. The original limit-fed diet was intended to contain (DM basis): 39% corn gluten feed, 39.3% corn, 10% rice hulls, 10% cottonseed hulls, 1.4%

[1]We appreciate the support of this project through product donations from Farmland Industries, Inc. (Kansas City, Missouri).

[2]All authors are associated with Southwest Research and Extension Center, Hope.

Farmland R-1500 premix, and .3% urea. Intake problems were encountered during the step-up phase, with calves sorting feed ingredients and leaving rice hulls. Rice hulls were removed from the final diet. Composition of the final limit-fed diet and supplement fed to HAY treatment is shown in Table 1. The hay used in this trial was analyzed to contain 10% crude protein, .56 Mcal/lb NEm, and .30 Mcal NEg. The corn used in this trial contained 40 ppm aflatoxin, which was below the FDA safe feeding level (300 ppm) for growing cattle.

The calves were weighed on November 3, after a 16-hour shrink. The calves were removed from the limit feeding trial on January 4, and weighed on January 5, 1999 following a 16-hour shrink. Forty steers and 40 heifers were placed on stockpiled K-31 tall fescue, for a supplementation trial. The calves were allocated by previous treatment and gender. The remaining cattle were placed on interseeded wheat/ryegrass until February 15 and stocked at 2.5 calves/acre. On February 15, 72 of the cattle were placed on bermudagrass pastures interseeded with wheat and ryegrass and used on a stocking rate/grazing system study. These calves were also allocated to new treatments balanced for previous treatment and gender. Intermediate weights in the stocking rate/grazing system study were not shrunk weights. These weights were pencil shrunk four percent for use in this analysis.

Statistical analysis of cattle performance during the fall/winter dry-lot period was conducted by ANOVA. Least-square means were separated by predicted differences using pen(treatment) as the error term. Performance of the calves during the grazing period was analyzed by ANOVA. Effects of fall/winter dry-lot treatment on grazing performance, grazing treatment, and the dry-lot by grazing treatment interaction were analyzed using animal (pen) as the error term. When the interaction was not significant, it was removed from the model. In the presence of a significant treatment effect ($P < .10$), LS means were separated using predicted differences. Regression equations among limit-fed dry-lot performance and subsequent pasture performance were developed for both ADG and total gain on pasture.

Results and Discussion

Cattle BW, feed intake, cost of gain, and performance during the dry-lot phase are shown in Table 2. The initial BW were pencil shrunk 4% for comparison purposes. Cost of gain shown in Table 2 includes feed used during the step-up period, because those are costs associated with the differing systems used. Assumptions used in analysis of cost of gains are $85/ton hay cost, and $1.76/bushel corn cost and a $.30/animal daily charge for labor, facilities and other overhead. We used reported market cost on all other ingredients at time of the onset of the trial plus delivery and $10/ton milling charge. Limit-fed diets cost $90/ton and the 20% CP supplement cost $146.50/ton. All other costs (calf processing, vaccinations, etc.) were the same between treatments so were not included in cost analysis.

On November 3, after the initial step-up period, HAY calves weighed more than ($P < .05$) calves in LOW, MODERATE, or HIGH treatments. At the end of the dry-lot feeding period, HIGH calves weighed more ($P < .05$) than MODERATE, and HAY which were heavier ($P < .05$) than LOW. Average daily gain for the HIGH treatment was, as planned, higher than other treatments either over the entire dry-lot period or after the step-up period. Gains of the HIGH cattle were lower than planned during the step-up period due to lower than expected intake of the diet containing rice hulls. After corrections were made to the diet, consumption of the diet was adequate to meet the programmed gain, but overall gains were lower than originally planned. The HAY and MODERATE treatment had similar ($P = .78$) ADG over the entire dry-lot period. Feed efficiency (feed:gain) for the entire feeding period was best for the HIGH treatment and was poorest ($P < .05$) with LOW or HAY treatments. At the cost of feed ingredients for this trial, dry-lot cost of gain was higher ($P < .05$) for the HAY group than for the limit-fed groups, and gain for the HIGH group cost less ($P < .05$) than for the LOW group. Total cost per animal for the dry-lot period was lowest ($P < .05$) for the LOW group followed by MODERATE, HIGH, and HAY groups, respectively.

Performance during the subsequent grazing period is shown in Table 3. There were no pasture treatment x dry-lot treatment interactions ($P > .30$) so grazing performance is shown across pasture treatments. During the first grazing period, calves from the LOW treatment gained more ($P < .05$) than those from the MODERATE group which gained more ($P < .05$) than calves from the HIGH or HAY treatments. Weight gains during grazing periods two and three were not statistically different. During period four, calves in the HIGH treatment gained less ($P < .05$) than calves in the other treatments. Overall pasture ADG was lowest ($P < .05$) for calves in the HIGH group compared to HAY, MODERATE and LOW groups. Body weight after the first period on pasture tended ($P = .14$) to be affected by dry-lot treatment. Calves in the HIGH group tended to be heavier than those in the LOW, HAY and MODERATE groups. Weights for the HAY, LOW, and MODERATE treatments were not statistically different ($P > .11$), after the first grazing period. In March, BW of the HIGH treatment tended ($P < .15$) to be higher than HAY, LOW, or MODERATE. There was no difference in BW during April or May.

The compensatory gain during the first grazing period by calves in the LOW group was to be expected. With a 56% compensation of BW difference, the LOW treatment was not able to fully compensate on pasture for the reduction in BW gains during the dry-lot period. In a compilation of several Nebraska studies, Klopfenstein et al. (1999) reported a range of compensation in grazing calves from 18.7 to 88% after calves were fed to differing rates of gain through the winter. Conclusions were that compensatory gain on grass is variable and hard to predict, but is usually around 50 to 60% with full season grazing. Differences in pasture gain by the calves in MODERATE and HAY treatments may help explain the variability found in research. In the first grazing

period, MODERATE calves gained .55 lb/day more ($P < .05$) than HAY. The difference in pasture gain cannot be explained by compensatory effect because the BW of the groups were not different ($P = .40$) at the onset of grazing. NRC (1996) simulation estimated rumen pH to be 6.02 with the limit-fed diets, compared to 6.46 with the HAY diet. Feeding diets containing readily degradable carbohydrates may sustain similar ruminal microbial populations to what are required for degrading high quality forages used in the grazing program. These microbe populations may have been reduced while feeding the HAY diet and maintained by the limit-fed diet. These differences may indicate possible diet effects confounding rate of pre-grazing gain.

Regression analysis based on individual animal performance of the limit-fed treatments indicate the relationship between ADG before grazing (X) and subsequent pasture ADG (Y). This relationship was described by $Y = 1.92 - .22X$ ($P < .01$; $r^2 = .13$), indicating that for every pound ADG is increased in the dry-lot period pasture ADG is reduced by .22 lb/day. A similar relationship was developed between total dry-lot gain (X) and total pasture gain (Y). This relationship was described by $Y = 253 - .46X$ ($P < .01$; $r^2 = .19$), indicating that for every pound of additional gain in winter dry-lot period pasture gain is depressed by .46 lb. The r^2 for the equations are quite low indicating a large degree of variation and are similar to regression equations reported by McLean (1990).

Pasture cost of gain (Table 3) was determined using a $.525/animal fixed daily charge for pasture cost and overhead, which was divided by the overall pasture ADG and multiplied by 100 to get cost per cwt gain. Because of the higher rate of pasture gain, pasture cost of gain for the LOW treatment was lower ($P < .05$) than for HAY, MODERATE, or HIGH treatments. The overall cost of gain (total cost/animal divided by total gain/animal multiplied by 100) was higher ($P < .05$) for the HAY treatment than for LOW, MODERATE, or HIGH treatments. Gross return to each treatment was calculated by subtracting the overall cost of gain from a $79/cwt value of gain then multiplying by the total amount of gain. The value of gain was based on the 10-year average price at Oklahoma City National Stockyards of 400 lb steer in September ($85.86/cwt) and 665 lb feeder steer in April ($83.12/cwt) (Peel, 1995). The highest gross return ($/head) was with the HIGH treatment at $114.91, even though pasture performance was the lowest. The overall BW gains and better feed efficiency during the dry-lot period with the HIGH treatment was able to spread out costs compared to the other treatments. The lowest gross return was with the HAY treatment at $69.46 is a reflection of the high hay cost before the onset of the trial and the slight reduction in overall pasture performance, compared to MODERATE.

Implications

This research shows that calves limit-fed high-concentrate diets in dry-lot during the fall and winter, may have advantages in gain and economic performance during subsequent grazing periods over calves fed diets consisting of hay and supplement. The best overall economic performance was found with the dry-lot treatment with the highest rate of gain, indicating the importance of spreading costs over more pounds of gain, and the importance of gain over the entire ownership period, rather than only during grazing. For each pound increase in dry-lot ADG pasture performance is reduced by .22 lb/day but gross margin is increased.

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Table 1. Composition of limit-fed diet and supplement used during dry-lot period.

Ingredient	%, DM basis
Limit fed diet	
Corn	44.3
Corn gluten feed	44.3
Cottonseed hulls	10.0
Farmland R-1500	1.4
Urea	.3
Calculated composition	
% Crude protein	15.8
NEm Mcal/lb	.92
NEg Mcal/lb	.53
Supplement	
Corn gluten feed	89.1
Farmland R-1500	9.8
Salt	1.1
Calculated composition	
% Crude protein	21.6
NEm Mcal/lb	.83
NEg Mcal/lb	.48

Table 2. Effect of fall/winter growing diets on BW, ADG, cost of gain.

		Limit-fed			
Item	HAY	LOW	MODERATE	HIGH	*P*-value
Body weight (lb)					
9/25/98	403	398	394	401	.51
1/5/99	518[b]	454[c]	507[b]	561[a]	.01
ADG	1.17[b]	.59[c]	1.14[b]	1.60[a]	.01
Feed:gain	14.2[ab]	19.1[a]	8.91[bc]	7.45[c]	.02
Cost of gain, $/cwt	$96.99[b]	$145.11[a]	$74.17[bc]	$55.48[c]	.01
Cost, $/animal	$103.45[a]	$63.11[d]	$71.84[c]	$82.34[b]	<.01

[a-d] LS means within a row with different superscripts differ ($P < .05$).

Table 3. Effect of winter growing treatment on subsequent performance on pasture.

		Limit-fed			
	HAY	LOW	MODERATE	HIGH	*P*-value
Body weight, lb					
January	518[c]	454[d]	507[c]	561[b]	.01
February	533	516	540	581	.14
March	597	581	596	637	.15
April	664	643	661	695	.19
May	706	685	699	732	.24
Pasture ADG					
Period 1 - 1/5 to 2/16	.36[d]	1.49[b]	.91[c]	.60[d]	.01
Period 2 - 2/16 to 3/10	2.70	2.66	2.35	2.35	.63
Period 3 - 3/10 to 4/12	2.10	1.98	2.05	1.83	.49
Period 4 - 4/12 to 5/10	1.50[b]	1.53[b]	1.43[b]	1.33[c]	.07
Overall pasture ADG	1.53[c]	1.85[b]	1.61[c]	1.43[d]	<.01
Pasture cost of gain, $/cwt	37.88[b]	29.88[c]	35.76[b]	40.66[b]	.07
Overall cost of gain, $/cwt	58.74[b]	47.54[c]	46.42[c]	45.83[c]	.07
Gross margin, $/head[a]	69.46[c]	95.57[bc]	106.41[b]	114.91[b]	.08

[a] Calculated by subtracting cost of gain from a $79/cwt value of gain then multiplying amount of gain. Value of gain was determined using the 10-year average price at Oklahoma City National Stockyards of 400 lb steer in September ($85.86/cwt) and 665 lb feeder steer in April ($83.12/cwt).

[b-d] LS means in rows with differing superscripts differ ($P < .05$).

Limit-Fed, High-Concentrate Diets for Maintaining Beef Cows During Drought Periods in the Southeast United States[1]

Stacey Gunter, Paul Beck, Jeff Weyers, and Kim Cassida[2]

Story in Brief

One-hundred sixty spring-calving cows, after their calves were weaned, were stratified by age, body condition score, and BW, then sorted equally into 10 drought-stricken bermudagrass pastures (16 cows/pasture). Eight pastures of cows were fed four different high-concentrate diets formulated with corn or corn gluten feed and 20% roughage (two sources) for approximately 100 days and compared with two pastures of cows fed hay plus a supplement. Limit feeding of high concentrate diets decreased BW, but this decrease was probably the result of decreased fill because they did maintain body condition score compared to hay fed cattle. No negative symptoms were observed regarding calving or digestive function. Limit feeding of high concentrate diets to gestating cows during periods of drought seems to be a viable alternative to feeding hay when it is in short supply. Also, when grain prices are favorable, gestating cows can be maintained on the high-concentrate diets more cheaply than with hay plus supplements.

Introduction

Reducing the hay requirements for wintering beef cowherds was a hot topic in the fall of 1998 because of a prolonged, record setting drought in southern Arkansas. Many farmers were purchasing hay from the north and trucking it into the area. Because hay has a low bulk density and digestible energy concentration, purchased hay can be an expensive alternative relative to grains and by-product feeds. Research from Ohio (Loerch, 1996) has shown that beef cows can be maintained on limit-fed diets containing 17% orchard grass hay, 65% whole-shelled corn, and 17% of a high protein/mineral supplement. The Ohio research showed that the limit feeding of a high-concentrate diet resulted in a 49% reduction in feed cost compared to the feeding of $80.00 per ton hay plus a $150.00 per ton supplement. The purpose of the present study was to evaluate limit-fed diets for bred beef cows formulated from corn or corn gluten feed with two different roughage sources in order to replace the need for hay when wintering beef cows.

Materials and Methods

After their calves were weaned, 160 sixty spring-calving cows (approximate BW = 1,100 lb) were stratified by age, body condition score (BCS), and BW, then sorted equally into 10 drought-stricken bermudagrass pastures (16 cows/pasture). Forage height in the pasture average less than 2 in. Cows were fed (two pastures/diet) high-concentrate diets formulated with corn or corn gluten feed and 20% roughage (two sources) for approximately 100 days (Table 1). Corn gluten feed was selected because of its high energy (80 Mcal of NEm/cwt) and protein concentrations (24% CP), but relatively inexpensive cost ($74.00/ton). The two roughage sources examined were cottonseed hulls and reground rice hulls (16/80 screen). Diets were mixed daily in a mixer wagon (Knight Manufacturing; Brodhead, Wisconsin) and limit fed at the amount suggested in Table 2. Two pastures of cows were fed long-stem bermudagrass hay plus a corn gluten feed supplement as a control (Table 1). Diets were formulated to meet or exceed NRC requirements (NRC, 1996).

Cows were weighed and BCS determined at 28-day intervals starting on Setember 11, 1998. Cows were adapted to the diets by starting them on a 40% roughage diet then stepping up the diet by 10 percentage units of concentrate on a weekly basis until only 20% roughage remained in the diets. On a daily basis cows were observed for signs of bloating, acidosis, or diarrhea that might have occurred with diets high in sulfur and(or) starch approximately 4 hours after feeding.

Beginning on December 7, 1998, at the end of the limit-feeding period, cows were fed bermudagrass hay plus supplement until December 11,1998. Cows were then weighed in the morning to minimize shrink to determine fill recovered since limit feeding ended. Beginning on December 11, 1998, cows were fed bermudagrass hay and limit grazed on rye/wheat/ryegrass pasture until May 1. After May 1, 1999, pairs were grazed on bermudagrass pasture. Cows began calving on February 15, 1999; technicians recorded

[1]This project was partially supported by a gift from Farmland Industries, Inc. (Kansas City, Missouri).
[2]All authors are associated with the Southwest Research and Extension Center, Hope.

calving dates, calving ease scores, calf BW, and calf gender. The experiment was analyzed as a completely randomized design with the effects of treatment and the covariates (cow age and calving date) in the model. Least-square means were separated using contrasts.

Results and Discussion

At the beginning of the experiment (September 11), BW did not differ ($P > .10$) among treatments; cows had an average BW of 1,126 lb (Table 2). By October 13, the BW of limit-fed cows was less ($P < .08$) than for cows fed hay plus supplement. This decrease in BW of the limit-fed cows probably resulted from a reduction in gastrointestinal fill. Cows fed diets containing cottonseed hulls weighed more ($P < .05$) than cows fed rice hulls. On December 7, hay fed cows weighed more ($P < .08$) than limit-fed cows, furthermore, cows fed corn weighed less ($P < .05$) than cows fed corn gluten feed and cows fed cottonseed hulls weighed more ($P < .05$) than cows fed rice hulls. Corn contains less fiber than corn gluten feed, again, differences in BW probably result from differences in fill. Between December 7 and December 11, all cows were fed the long-stemmed grass hay plus supplement. Cows that had previously been limit fed rice hulls were still lighter ($P < .05$) than cows that were maintained on cottonseed hulls. But, the BW of limit fed cows did not differ ($P > .10$) from cows fed hay plus supplement. During the last four days, limit-fed cows gained about 45 lb or 5% of their BW. The increase in BW noted with limit-fed cows would have been the result of increased fill. The 13 lb loss in BW by cows fed hay plus supplement did not differ ($P > .15$) from zero and is probably the result of random error.

Cow BCS was not affected by dietary treatment; it was noted that there was a general increase from September 11 to December 7. We did feed the cows to meet their NEm requirements, but they gained approximately .5 of a BCS during the feeding period. Some of the increase noted in BCS is probably the result of the thinner cows putting on over a full BCS each and the extremely mild weather they experienced in the fall of 1998. We saw no bloating or signs of acidosis. Furthermore, there were no cows with diarrhea that might have occurred with diets high in starch like with corn or high in sulfur like corn gluten feed.

Cows fed hay plus supplement consumed about 20 lb more feed DM daily than cows limit fed. Furthermore, because of the higher energy concentration in corn and rice hulls than corn gluten feed and cottonseed hulls, respectively, cows fed corn and rice hulls required ($P < .05$) less feed to maintain BW and BCS. The cows fed hay and supplement cost approximately $.99 to feed daily ($70.00/ton of hay; $74.00/ton of corn gluten feed), but because only one third the feed was required with the high concentrate diets, these cows only cost approximately $.49 to feed daily averaged across all treatments.

There were no differences detected among treatments in calving date ($P = .57$), BCS at calving (average = 6.1; $P = .80$), calf BW at birth (average = 78 lb; $P = .97$), or calving ease (average = 1; 1 = unassisted birth, 5 = hard pull).

Implications

Limit feeding of high concentrate diets to gestating cows during periods of drought seems to be a feasible alternative to feeding hay when it is unavailable. Also, when grain prices are favorable, gestating cows can be maintained on the high-concentrate diets more cheaply than with hay plus supplements.

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Table 1. Diets for mature beef cows offered limit-fed high-concentrate diets.

	Treatments[a]				
Item	Supplement	Corn/CSH	Corn/RH	CGF/CSH	CGF/RH
Diet ingredients, % as fed					
Corn, cracked	—-	71.4	71.5	—-	—-
Corn gluten feed	90.3	—-	—-	79.3	79.4
Cottonseed hulls	—-	19.4	—-	19.3	—-
Rice hulls, ground	—-	—-	19.3	—-	19.2
Cottonseed meal	—-	6.9	6.9	—-	—-
Urea	—-	.9	.9	—-	—-
Salt	1.0	—-	—-	—-	—-
Farmland R-1,500[b]	8.7	1.4	1.4	1.4	1.4
Diet composition[c], % of DM					
Dry matter	88.7	96.3	96.6	96.1	94.5
Crude protein	25.1	16.6	14.4	22.8	21.2
Neutral detergent fiber	37.9	29.4	34.8	49.4	51.7
Acid detergent fiber	9.4	15.3	22.2	21.7	26.0
Calcium	2.84	.53	.54	.39	.46
Phosphorus	.91	.44	.39	.78	.75
Ash	16.8	4.6	8.7	6.0	10.4
NEm, Mcal/100 lb[d]	78	80	91	67	78

[a] Supplement = hay + supplement, Corn/CSH = corn + cottonseed hulls, Corn/RH = corn + rice hulls, CGF/CSH = corn gluten feed + cottonseed hulls, and CGF/RH = corn gluten feed + rice hulls.
[b] Composition: Ca, 26%; P, 1%; NaCl, 7.5%; K, 5%, Vitamin A, 80,000 IU/lb, and 1,500 mg of monensin/lb.
[c] Analyzed.
[d] Calculated.

Table 2. Effect of limit-fed high concentrate diets on BW and BCS fed to mature beef cows.

Item	Treatment[a]					SE
	Hay	Corn/CSH	Corn/RH	CGF/CSH	CGF/RH	
BW, lb						
9/11/98	1,120	1,111	1,134	1,173	1,082	28.9
10/13/98[ce]	1,191	1,101	1,097	1,154	1,057	26.7
11/9/98[c]	1,181	1,102	1,097	1,186	1,085	36.4
12/7/98[cde]	1,213	1,101	1,074	1,208	1,098	34.5
12/11/98[e]	1,187	1,149	1,131	1,247	1,130	33.7
Fill gained last 4 day						
Pounds[c]	-13	41	51	40	41	16.2
Percentage of BW[c]	-1.2	4.3	5.7	4.1	4.6	1.9
BCS, 1 to 9						
9/11/98	5.6	5.6	5.8	5.7	5.4	.14
10/13/98	5.6	5.7	5.5	5.7	5.3	.25
11/9/98	6.1	6.0	6.2	6.2	5.8	.17
12/7/98	6.2	6.1	6.1	6.4	6.1	.12
Feed DM intake[b], lb/d as-fed						
9/11 to 10/12[cde]	19.4	9.9	9.2	11.1	10.5	.02
10/13 to 11/8[cde]	27.3	11.4	10.3	13.8	12.0	.50
11/9 to 12/6[cde]	31.3	12.6	10.8	15.0	12.9	.41

[a]Hay = hay + supplement, Corn/CSH = corn + cottonseed hulls, Corn/RH = corn + rice hulls, CGF/CSH = corn gluten feed + cottonseed hulls, and CGF/RH = corn gluten feed + rice hulls.
[b]Hay treatment DM intake = hay DM + supplemental DM, Corn/CSH, Corn/RH, CGF/CSH, and CGF/RH treatments equals total DM of the mixed diets actually fed.
[c]Contrast = hay vs limit-fed diets ($P < .08$).
[d]Contrast = corn vs corn gluten feed ($P < .05$).
[e]Contrast = cottonseed hulls vs rice hulls ($P < .05$).

Performance of Growing Calves Supplemented with Bioplex® Copper Pre- or Post-Shipping to a Feedlot[1]

Stacey Gunter[2], Paul Beck[2], Beth Kegley[3], Kathryn Malcom-Callis[4], and Glenn Duff[4]

Story in Brief

A growing, transporting, and feedlot receiving trial was conducted to determine the benefits of Bioplex® copper supplementation on the performance and health of cattle grazing winter annual pasture before and after shipping to a high-plains feedlot. Cattle were supplemented with 1.5 g of Bioplex copper (10% copper) 30 days before shipping while grazing wheat/rye/ryegrass pasture in South Arkansas. Then after arriving at the feedlot, one-half of the control (no copper) and and one-half the supplemented cattle received 1.5 g of Bioplex copper daily (2 x 2 factorial) for a 42-day receiving period. It seems that supplementation of copper deficient diets with Bioplex copper before shipping to a feedlot increased BW gain, and the BW advantage was maintained through the receiving period at the feedlot. No benefit relative to performance was recorded when Bioplex copper was fed at the feedlot. There were no signs of clinical disease at the feedlot; thus, no conclusions could be drawn considering the immune response or disease resistance of the cattle used in this trial.

Introduction

Copper is an essential trace mineral for cattle grazing on Coastal Plains soils in the southern United States. These soil include millions of acres, following the coastline from Virginia to Texas (Brady, 1974). With stocker cattle undergoing stress, copper requirements range from 10 to 15 ppm depending on animal factors (NRC, 1996) and content of interfering substances such as molybdenum or iron (Gengelbach et al., 1997). Deficiency of copper results in decreased growth rate, anemia, and changes in hair color (McDonald et al., 1988). Copper also affects immune function in cattle (Gengelbach and Spears, 1998).

Winter annual grasses grown on Coastal Plain soils are shallowly rooted because of frequent rainfalls. The topsoils associated with these soil types are noted for their low organic matter, base saturation, and poor cation-exchange capacity (CEC). Hydrogen ions are released from plant root hairs as they grow, these hydrogen ions force cations, like copper, to be released into soil water and then assimilated with the absorptive surfaces of the roots. However, when soils have a low CEC and base saturation, cations are not as easily released from the soil's exchange complex resulting in plant tissue low in the minerals in question (Brady, 1974). Thus, this study was designed to determine the effect of supplementation with Alltech Bioplex® copper, a source of copper in the proteinate form, on calves backgrounded on winter annual pasture, either before shipment to a feedlot or after arrival.

Materials and Methods

Eighty-four Angus- and Brangus-sired steers were used to determine the effects of feeding Bioplex copper (Alltech, Inc.) before shipping or during the feedlot receiving period. Steers were weaned from the Southwest Research and Extension Center cow herd in October of 1997. At weaning, the calves were processed, including treatment for internal and external parasites (Ivomec®, Merck & Co., Inc., Whitehouse Station, New Jersey), vaccinated with a 7-way Clostridial antigen (Vision 7®, Bayer Corp., Shawnee, Kansas) and IBR-PI_3-BVD-BRSV (Bovishield 4®, SmithKline Beecham Animal Health, Exton, Pennsylvania). Calves were then fed hay and 2 lb/animal/day of a high-protein supplement (30% CP). On February 19, 1998, the calves were weighed after a 16-hour shrink (cattle were held in a corral with no feed or water), implanted with Component-S® (Ivy Laboratories, Inc., Overland Park, Kansas) separated by treatment, and placed on 12 two-acre bermudagrass pastures interseeded with wheat, rye, and ryegrass. From February 19 to April 16, the cattle were fed 2 lb/animal/day of corn, containing a commercial mineral premix (Vigortone 46S, PM Ag Products, Inc., Cedar Rapid, Iowa), three times per week. On April 16, the cattle were weighed after a 16-hour shrink

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[2] Southwest Research and Extension Center, Hope.
[3] Department of Animal Science, Fayetteville.
[4] Clayton Livestock Research Center, New Mexico State University, Clayton.

and copper supplementation began.

Composition of supplements is shown in Table 1. Corn supplements fed three times per week (pro-rated to equal 2 lb/animal/day on a as-fed basis) contained a commercial mineral mix (Vigortone 46S), supplied 200 mg of monensin (Rumensin®; Elanco Animal Health) and either had no additional copper or .165% Bioplex copper (Alltech, Inc.; 10% copper). Nineteen ppm supplemental copper (copper sulfate) was supplied by the mineral premix to the control calves for a total of 21 ppm copper, and 165 ppm additional was fed to Bioplex copper calves for a total of 186 ppm copper. On May 15, the calves were weighed after a 16-hour shrink, shipped to a local receiving yard (F & F Cattle Company, Hope), co-mingled with calves purchased from a local auction, and held on hay and water until May 17. The steers were then shipped from southwest Arkansas to the Clayton Livestock Research Center in Clayton, New Mexico (630 miles, 14-hour transit). Steers arrived at 0730 and were processed, including: branding, treatment for internal and external parasites (Ivomec Pour-On; Merial Animal Health, Iselin, New Jersey), vaccinated with a 7-way clostridial antigen (Fortress 7®; Ft Dodge Animal Health, Overland Park, Kansas), and IBR-PI3-BVD-BRSV (Bovishield 4), implanted with Ralgro® (Schering-Plough Animal Health Corp., Union, New Jersey), rectal temperature was determined, and steers were sorted into treatment pens. Treatment pen assignments were the same as pasture assignments with half of each pre-shipping treatment groups receiving Bioplex copper. All cattle were fed a 70% concentrate diet (Table 2) throughout the 42-day receiving period and observed daily for bovine respiratory disease. After the initial weight at the feedlot, weights were taken unshrunk on d 14, 28, and 42 of the feedlot-receiving period before the morning feeding.

Treatments were applied as a completely randomized design using a 2 x 2 factorial arrangement of treatments. Factors included receiving the Bioplex copper during the grazing period and receiving the Bioplex copper during the feedlot-receiving period. Pen was considered the experimental unit for all calculations. Least-square means and predicted differences were used to separate the effect of copper treatments. Cattle weights were heavier for Bioplex copper calves on April 16, so BW was used as a co-variate in all subsequent statistical analysis.

Results and Discussion

The effects of pre-shipping supplementation with Bioplex copper on pasture on BW variables, ADG, and feed DMI and efficiency did not interact ($P > .10$) with Bioplex copper supplementation at the feedlot. Beginning BW of the grazing calves on April 12 was 630 lb (Table 3). Calves receiving Bioplex copper on pasture tended to be 1.2% heavier (688 vs. 680, respectively; $P < .11$) by the end of the grazing period and had a 17.6% higher ADG (2.0 vs 1.7, respectively; $P < .11$) compared to control calves. At the end of the feedlot receiving period, calves fed Bioplex copper on pasture were 14 lb heavier than control calves (926 vs. 912, respectively, $P < .05$), but ADG was only numerically higher (5.7 vs 5.6, respectively, $P = .34$). Feedlot feed efficiency and DMI was not affected by Bioplex copper supplementation on pasture (Table 3).

Average daily gain of calves that were supplemented with Bioplex copper while grazing was not affected by Bioplex copper supplementation during the feedlot-receiving phase (Table 3), initial feedlot BW averaged 678 lb for Bioplex copper calves and 686 lb for control calves ($P = .22$). Body weight and ADG at the end of the feedlot receiving phase was not affected by feedlot Bioplex copper supplementation compared to control calves (914 vs 923 lb, $P = .15$; and 5.6 vs 5.7 lb, respectively, $P = .76$). Also, feed efficiency and DMI at feedlot did not differ as a result of feedlot Bioplex copper supplementation.

Table 4 shows the effects of copper supplementation when fed on pasture and(or) during the feedlot receiving period. Body weight at the end of the pasture phase and pasture ADG tended to be higher ($P < .11$) for steers on the Bioplex copper/control treatment than for steers on the control/Bioplex copper and control/control treatments. Body weights of steers on the Bioplex copper/control treatment at the end of the feedlot-receiving phase were higher ($P < .05$) than for steers on the control/Bioplex copper or control/control treatments. Feedlot ADG was not affected by the supplementation of Bioplex copper either before or after shipment to the feedlot. No differences were found in rectal temperature, or morbidity during the 42-day feedlot receiving period. No cattle were diagnosed with bovine respiratory disease complex during the receiving period.

It seems that supplementation of copper deficient diets with Bioplex copper before shipping to a feedlot increases BW gain, and the BW advantage is maintained through the receiving period at the feedlot. There were no observed signs of disease at the feedlot, so no conclusions can be drawn considering the immune response or disease resistance of the cattle used in this trial. Table 2 shows the composition of the feedlot diet. When the feedlot diet was analyzed with the NRC computer simulator (NRC, 1996), it indicated a daily copper requirement of 99 mg/day was oversupplied by 136 mg/day (total intake, 235 mg/day). This may explain the differences in effect found when the cattle were on pasture compared to at the feedlot. The premix supplied to the grazing cattle was considered a complete mineral premix and considered well fortified with copper; yet because of the characteristics of the soil, copper levels were still marginal in meeting the requirements of cattle winter annual pasture grown on the Coastal Plain.

Implications

It seems that supplementation of copper deficient diets with Bioplex copper before shipping to a feedlot increases BW gain, and the BW advantage is maintained through the receiving period at the feedlot when cattle are grazing winter annual grasses grown on Coastal Plain soils.

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Table 1. Composition (as-fed basis) of supplement offered to grazing steers.

Item	% As-fed	
	Bioplex® copper	Control
Supplement composition		
Ground corn	89.375	89.541
Premix	10.334	10.334
Rumensin 80	.125	.125
Alltech Bioplex® copper	.165	.000
Chemical composition		
Crude protein, %	5.8	5.8
Total digestible nutrients, %	76.0	76.1
Monensin, mg/lb	100	100
Copper, ppm	186	21

Table 2. Composition (DM basis) of the basal 70% concentrate feedlot receiving diet.

Item	% of DM
Diet composition	9.9
Sudangrass hay	19.8
Alfalfa hay	9.5
Whole shelled corn	46.7
Steam-flaked corn	3.8
Soybean meal	4.9
Molasses	4.9
Fat (yellow grease)	1.9
Limestone	.7
Dicalcium phosphate	.5
Salt	.3
Urea	.8
Ammonium sulfate	.2
Premix	1.0
Chemical composition	
Dry matter	84.9
Ash	6.6
Crude protein	12.1
Acid detergent fiber	14.7
Copper, ppm	24

Table 3. Main effects of Bioplex® copper fed to grazing steers during final 29 days pre-shipping to a feedlot and during the feedlot receiving-phase on BW, performance, DMI, and feed efficiency[a].

Effects/item	Bioplex® Copper	Control	SE	*P*-value
Grazing effects				
Initial pasture BW, lb	630	630	—-	—-
Final pasture BW, lb	688	680	2.9	.11
Pasture ADG, lb	2.0	1.7	.1	.11
Initial feedlot BW[b], lb	686	678	4.2	.18
Final feedlot BW, lb	926	912	6.9	.04
Feedlot ADG, lb	5.7	5.6	.1	.34
Feed DMI, lb/d	21.6	21.3	.1	.77
Feed efficiency, feed/gain	3.8	3.8	.1	.22
Feedlot effects				
Initial pasture BW, lb	630	630	—-	—-
Final pasture BW, lb	682	686	2.9	.46
Pasture ADG, lb	1.8	1.9	.1	.46
Initial feedlot BW[b], lb	678	686	4.3	.22
Final feedlot BW, lb	914	923	6.9	.15
Feedlot ADG, lb	5.6	5.7	.1	.76
Feed DMI, lb/d	21.3	21.6	.1	.76
Feed efficiency, feed/gain	3.8	3.8	.1	.89

[a]Least-square means using initial pasture BW as a co-variable.
[b]Off truck weight.

Table 4. Effect of Alltech Bioplex® Copper fed to steers while grazing or during feedlot receiving phase[a].

	Treatment				
	BioCu[b]/BioCu	BioCu/CON	CON/BioCu	CON/CON	SE
Initial pasture BW, lb	630	630	630	630	—-
Final pasture BW, lb	684[de]	692[d]	681[e]	679[e]	4.2
Pasture ADG, lb	1.9[de]	2.1[d]	1.8[e]	1.7[e]	.1
Initial feedlot BW[c], lb	683	690	674	682	4.3
Final feedlot BW, lb	921[fg]	930[f]	907[g]	917[g]	6.9
Feedlot ADG, lb	5.7	5.7	5.5	5.6	.1
Body temperature, °F	102.6	102.5	102.5	102.4	.02

[a] Least-square means using initial pasture BW as a co-variable.
[b] BioCu = Bioplex® copper, CON = control.
[c] Off truck weight.
[d,e]Means in rows with differing superscripts differ ($P < .11$).
[f,g]Means in rows with differing superscripts differ ($P < .05$).

Escape Protein for Growing Cattle Grazing Stockpiled Tall Fescue[1]

Paul Beck, Stacey Gunter, Mike Phillips, and Kim Cassida[2]

Story in Brief

Forty steers and 40 heifers were allocated by gender and previous treatment to eight 12-acre Kentucky-31 tall fescue pastures. Each pasture was assigned to one of four supplement treatments to test the ability of either supplemental energy or two levels of supplemental escape protein to correct a possible ruminal imbalance of protein and energy found in high quality forages. Supplementation treatments consisted of 1) no supplemental feed offered (CONTROL), 2) supplemental corn (CORN), 3) a 22% CP supplement designed to supply 100 g/day escape protein, a low level of escape protein supplementation (LEP), or 4) a 42% CP supplement designed to supply 200 g/day of escape protein, a higher level of escape protein (HEP). Supplements were designed to supply 200 mg/day of lasalocid, and free-choice mineral was offered to all calves in weather vane type feeders. Statistical analysis was conducted using steers only, heifers only and with both genders in the data set. Combined gender analysis indicated that performance of calves grazing fescue is increased by supplementation, but gains were not improved with the addition of escape protein to energy supplements. Performance of steers was increased by supplementation, while supplementation did not statistically increase gains in heifers. The different responses due to gender indicate energy supplementation is required in steers grazing stockpiled fescue in the winter and spring, but is unnecessary in heifers.

Introduction

In high quality forages an imbalance of available total digestible nutrients (TDN) and crude protein (CP) in the rumen may occur causing inefficient use of degradable nitrogen (N). The ratio of TDN in relation to CP (TDN:CP) is balanced at < 7:1. Above this ratio, cattle performance and forage intake will be increased with the supplementation of rumen degradable protein such as soybean meal. Ruminal ammonia concentrations begin to increase when the TDN:CP ratio falls to 4:1, indicating rumen microbes are not incorporating N into microbial protein as fast as it is released into the rumen. At ratios < 3:1, large losses of N to the animal occur, because excess N is excreted in the urine. Tall fescue in the fall and early spring has been reported to have CP concentrations ranging from 15 to 25% and TDN levels of 60 to 75% (Phillips et al., 1993). These characteristics create unbalanced TDN:CP ratios that are potentially less than 4:1. Thus, even with high quality forages, growth of cattle may be limited by protein flow to the small intestine. This limitation can be met with direct supplementation of protein supplements that escape fermentation in the rumen or with supplementation energy to correct the imbalance and create more microbial protein that is ultimately available to the animal. This research was conducted to test the effects of supplementation with either energy or two levels of bypass protein on performance of growing cattle grazing stockpiled fescue.

Materials and Methods

On January 4, 1999, 40 steers and 40 heifers were removed from a dry-lot study and randomly assigned to eight groups by gender and previous treatment. A full description of the previous treatments has been reported by Beck et al. (1999). The cattle were weighed after a 16-hour shrink and then randomly assigned to eight pastures that were 12 acres in area (.83 animals/acre). All groups had free choice access to a commercial mineral mix (Vigortone 46smg) fortified with additional copper sulfate. The mineral mixture included 11.0 to 13.2% calcium, 6% phosphorus, 15.5 to 18.5% salt, 10% magnesium, .4% potassium, 1,528 ppm copper, 26.4 ppm selenium, and 3,000 ppm zinc. Supplement treatments consisted of 1) no supplemental feed offered (CONTROL), 2) supplemental corn (CORN), 3) a 22% CP supplement designed to supply 100 g/day escape protein - Low Escape Protein (LEP), or 4) a 42% CP supplement designed to supply 200 g/day of escape protein - High Escape Protein (HEP). The supplement composition is shown in Table 1. Fish meal, feather meal, and poultry blood meal were blended on an equal protein basis and blended with corn to supply the daily supplemental escape protein. Supplements were fed at a rate of 2.8 lb/animal five days a week (equal to 2 lb/animal/day) and were designed to supply 200 mg/day lasalocid (Bovatec; Roche Vitamins, Inc.; Parsippany, New Jersey). The escape protein level for each supplement was calculated by NRC

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[2] Southwest Research and Extension Center, Hope.

(1996) computer simulation using book values for ingredient CP and ruminal CP escape.

Supplements were fed to each group in the pasture between 0700 and 0900 each morning when the cattle were observed to be finished with the morning grazing activity. For the first week of the trial molasses was added to all of the supplements to promote intake. Molasses was removed completely from the supplement at the start of the second week and no problems were observed in consumption of supplements. The cattle were weighed each at 28 to 35-day interval after a 16-hour shrink to equalize fill differences. None of the cattle in this study received implants, so the heifers could be used as replacements for the breeding herd. Supplement conversion was calculated from pasture means of performance and supplement intake. Supplement consumption was not measured individually, so supplement conversion was not statistically analyzed.

The data were analyzed as a completely randomized design using pasture as the experimental unit. Supplement treatment, gender, previous treatment, and the gender x supplement interaction, and previous treatment x supplement interaction were tested. There were no significant interactions ($P < .17$) so they were removed from the final model. Weight at the onset of the trial was included as a covariate in the analysis to remove variation among treatments. Least-square means for supplement treatment were separated by predicted differences when a significant ($P < .10$) treatment effect was found. Analyses was conducted on all animals (steers and heifers combined) and each gender individually to identify possible differences in effects of supplementation due to different stages of maturity associated with gender.

Results and Discussion

The escape protein supplements were designed to supply a balanced mixture of amino acids that would bypass to the small intestine. Feather meal and poultry blood meal are common byproducts from the poultry slaughter industry. These byproduct protein meals are complementary in amino acid profile, yet lacking in the amino acid methionine. Feather meal contains large amounts of cysteine, a sulfur amino acid required by the body, but it is converted from methionine so there is no nutritional requirement for it. Klemsrud and Klopfenstein (1999) showed that cysteine can supply up to 51% of the total sulfur amino acids required, so an inexpensive escape protein source like feather meal can be used to replace other more expensive ingredients. Fish meal is an escape protein supplement with a balanced amino acid profile and is rich in methionine, thus fish meal was included in the supplement to supply methionine to the supplement.

The effect of supplement treatments in the combined data set and for each gender separately are shown in Table 2. In the combined analysis, final BW increased ($P < .01$) by 29, 26, and 37 lb for CORN, LEP, and HEP supplementation strategies, respectively. There was no statistical difference in final weight as a result of supplement type, but CORN and LEP performed similarly while weights of HEP calves were 8 lb higher than CORN. Average daily gains were improved ($P < .07$) by supplementation. Addition of escape protein yielded no statistical advantages over CORN, but a numerical advantage of .07 lb/d was observed for HEP treatment compared to the CORN treatment. Supplement conversion (pounds of supplement required per pound additional gain) was the best for the HEP treatment at 6.7; while LEP and CORN treatments were less efficient (9.5 and 8.7, respectively).

When the statistical analysis was limited to steers, BW were increased ($P < .01$) by 43 lb by CORN and HEP and tended ($P = .06$) to be 22 lb greater for LEP compared to CONTROL. The CORN and HEP supplementation strategies increased ($P < .01$) ADG by .36 lb/day and LEP tended ($P = .06$) to increase ADG by .19 lb/day compared to CONTROL. Supplement conversion was 5.6 for CORN and HEP, and 10.5 for LEP.

Heifer BW was not improved ($P = .32$) with supplementation. Supplementation numerically increased BW and ADG by 13, 28, and 32 lb and .12, .24, and .27 lb/day with CORN, LEP, and HEP supplementation compared to CONTROL. Supplement conversion was the best for HEP (7.4) and LEP (8.4).

Differences in supplement effect due to gender were expected; the heifers had no increase in performance due to supplementation. Steers had lower performance with LEP than with HEP or CORN and added escape protein did not increase gains compared to CORN. The steers may have been more efficient than heifers in utilizing the protein in the forage when supplemental energy was provided or needed more protein to maximize performance than heifers. The lack of increased performance with added escape protein compared to energy supplementation may be explained by the amino acid sparing effect of ionophores like lasalocid, where ionophores have been shown to decrease protein deamination in the rumen (Russell, 1991). Horn et al. (1990) reported increased gains of .50 lb/day and supplement conversion of around 6.5 with steers grazing wheat pasture fed a self-limiting energy supplement containing rumensin. Supplement conversion was not statistically analyzed, so no statements can be made concerning the differences between treatments. Economics of a supplementation program depends on relative feed costs and profit potential of the calves. Supplement conversions of 5.6 to 6.7 are much lower than values of 8 to 10 commonly associated with energy supplementation programs which improves the economical potential of a supplementation program (Horn and McCollum, 1990). McCollum and Horn (1990) stated that when supplementation programs increase ADG and have a low supplemental feed to added gain ratio, forage intake was increased by the supplementation. Antiquality factors (endophytes) in the fescue may have led to lower increases in forage intake and lower ADG than would be expected with supplementation.

Figure 1 shows the effect of supplementation during each period on the performance of both steer and heifers. It

appears that the HEP supplementation promotes more gain compared to CORN and LEP, particularly as it is fed later into the spring. As the season progresses, stem elongation occurs as the cool season forages become reproductive. The associated decrease in forage quality may cause a limitation of protein at the small intestines of the animals.

Conclusions

Grazing performance was improved with the supplementation of CORN and HEP to steers grazing tall fescue. Additional escape protein had no effect on performance compared to CORN. Performance of heifers was not statistically improved with supplementation. In the combined analysis supplement conversion (lbs of feed required per lb additional gain) was best with 200 g of supplemental escape protein/day. Escape protein appeared to improve animal performance later in the spring as forage quality of tall fescue declines.

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Table 1. Composition of supplements fed to cattle grazing tall fescue.

Ingredient	Supplement, % of DM		
	CORN	LEP[a]	HEP[b]
Corn	99.85	79.85	52.85
Fish meal	-	8.10	19.04
Feather meal	-	6.12	14.38
Blood meal	-	5.78	13.58
Bovatec B-68	.15	.15	.15
Calculated composition			
% Crude protein	8.0	22.5	42.2
% TDN	89	84	79
Lasalocid (mg/day)	200	200	200
Escape Protein (g/day)	25	100	201

[a] LEP - Low Escape Protein supply 100 g/day of escape protein.
[b] HEP - High Escape Protein supply 200 g/day of escape protein.

Table 2. Effect of supplemental energy or escape protein on performance of cattle grazing tall fescue.

Item	Treatment				*P*-Value
	Control	Corn	LEP	HEP	
Combined					
Analysis					
Initial BW	563	563	563	563	-
Final BW	699[c]	728[b]	725[b]	736[b]	.07
ADG	1.14[c]	1.37[b]	1.35[b]	1.44[b]	.07
Supplement conversion[a]	-	8.7	9.5	6.7	
Steers					
Initial BW	594	594	594	594	-
Final BW	734[c]	777[b]	756[bc]	777[b]	.02
ADG	1.16[c]	1.52[b]	1.35[bc]	1.52[b]	.02
Supplement conversion[a]	-	5.6	10.5	5.6	
Heifers					
Initial BW	532	532	532	532	-
Final BW	665	678	693	697	.32
ADG	1.11	1.23	1.35	1.38	.32
Supplement conversion[a]	-	16.7	8.3	7.4	

[a]Pounds supplemental feed per lb added gain.
[bc]Least-square means within rows with different superscripts differ ($P < .05$).

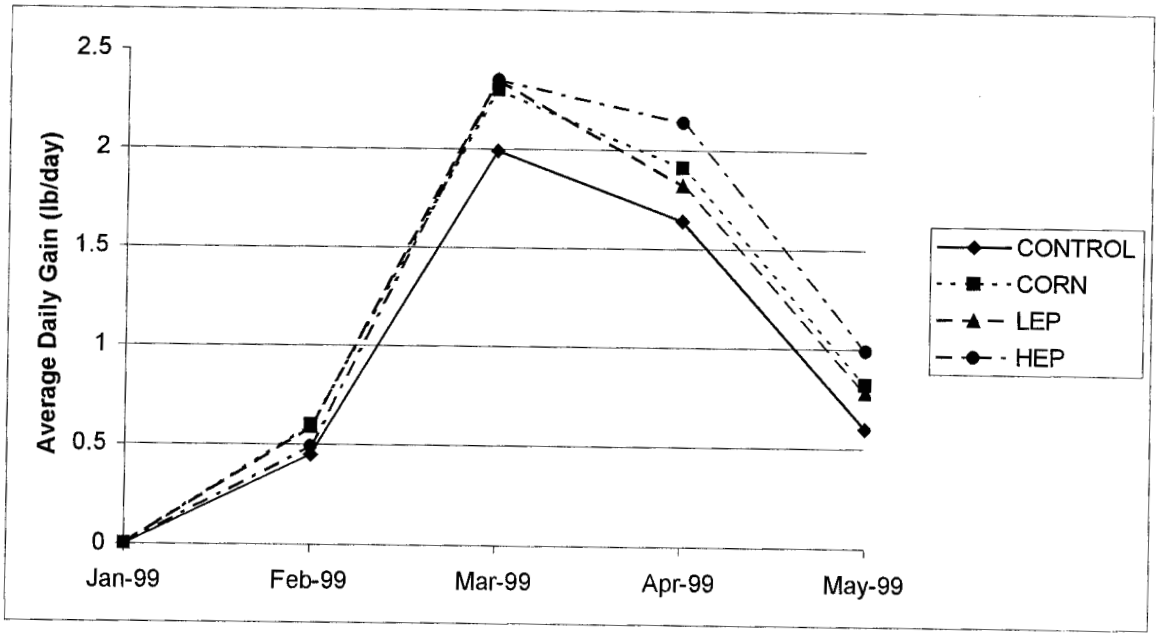

Fig. 1. Effect of supplementation on growth of steers and heifers during each period of fescue supplementation trial.

Genotype x Environment Interactions in Angus, Brahman, and Reciprocal Cross Cows and their Calves Grazing Common Bermudagrass, Endophyte-Infected Tall Fescue Pastures, or Both Forages

A. Hayden Brown[1], Jr., Michael A. Brown[2], Wesley G. Jackson[3], and James R. Miesner[3]

Story in Brief

Reproductive and preweaning data on 190 Angus (A x A), Brahman (B x B), and reciprocal-cross cows (A x B, B x A)and 434 two- and three-breed cross calves managed on common bermudagrass (BG), endophyte-infected tall fescue (E+), or a combination of both forages (ROT) were used to evaluate the interaction of forage type with individual and maternal heterosis and maternal and grandmaternal breed effects. Cows were born from 1988 to 1991 and calves from 13 Polled Hereford sires were born from 1995 to 1997. Individual heterosis for calving rate was larger on E+ compared to BG or ROT ($P < .05$), while maternal effects were larger on BG than ROT ($P < .10$). Grandmaternal effects were evident on BG ($P < .10$) and E+ ($P < .01$) but not ROT. Forage effects were generally substantial for 205-day weight, weaning hip height, and weaning weight:height ratio with BG highest, ROT intermediate, and E+ lowest, and maternal heterosis for these traits was generally greater on E+ than BG ($P < .10$). Grandmaternal breed effects for 205-day weaning weight, weaning hip height, and weaning weight:height ratio were not important on any forage. Individual heterosis for weaning weight per cow exposed was significant ($P < .01$) within all forage groups and was significantly greater on E+ ($P < .01$) than BG or ROT, while maternal breed effects were not significant for any forage. These data suggest more advantage to Brahman-cross cows over purebreds on E+ than a similar comparison on BG. These data also suggest that moving cows and calves from E+ to BG in the summer will alleviate some but not all of the deleterious effects of E+ on calf growth but may be more beneficial for reproductive traits in purebred cows.

Introduction

In the Mid-South United States, common bermudagrass (BG) and endophyte-infected tall fescue (E+) are the major available warm-season and cool-season forages. The problems with endophyte-infected tall fescue have been extensively documented. Losses in milk production, weaning weight, and reproduction have been reported. Brown et al. (1997) reported that F_1 cows from the Brahman and Angus breeds and their three-breed cross calves were more tolerant of the E+ compared to their purebred contemporaries, when cows were managed on BG and E+ all year. Sleper and West (1996) suggested that removal of cows from E+ during the summer months is appropriate management of E+ to help alleviate problems associated with this forage. However, there has been little evidence in the literature to document the effects of removal during the summer. Moreover, there is some evidence that heterosis, and(or) breed effects are not consistent across production environments (Brown et al., 1997). There is little documentation of interactions of genetic effects with management systems involving year-round management on BG, E+, or a system using both forages during appropriate grazing seasons. Consequently, the objective of this research was to evaluate the reproductive performance of Angus, Brahman, and reciprocal-cross cows and the preweaning performance of their three-breed cross calves, when cows and calves were managed on BG, E+, or a combination of the two forages.

Experimental Procedures

Approximately 190 Angus (A x A), Brahman (B x B), and reciprocal-cross cows (A x B and B x A) born in 1988 to 1991 and 434 two- and three-breed cross calves were used to evaluate the effect of forage management system on reproductive and preweaning performance. For crossbred cows in this study, sire breed of cow is listed first and dam breed of cow (breed of cow's mother) is listed second (i.e. an A x B cow was produced from a mating of an Angus sire and a

[1] Department of Animal Science, Fayetteville.
[2] USDA, ARS, Grazinglands Research Laboratory, El Reno, Oklahoma 73036
[3] USDA, ARS, Dale Bumpers Small Farms Research Center, Booneville.

Brahman dam). Cows were managed on either BG or E+ with all breed types represented in each pasture. After weaning in the fall of 1994, approximately 10 cows from each breed group in each forage were randomly assigned to a new forage management treatment, i.e., E+ in the fall and spring (approximately November-May) and BG in the summer (June-October). Consequently, there were three 40-acre pastures of BG, three 40-acre pastures of E+, and two pairs of 40-acre BG and E+ pastures used in the rotational system (ROT). Pastures were paired to result in two BG/E+ combinations consisting of 80 acres per pair (40 for each forage type). Stocking rates were approximately .5 head/acre for BG and E+ and an average of approximately .5 head/acre on ROT (approximately 1.0 head/acre on BG in summer and approximately 1.0 head/acre on E+ in fall and spring). Pastures were fertilized with a total of 138 lb/acre of N in two applications; early May and mid-July for BG and early March and early October for E+. Other soil amendments (P and K) were applied as suggested by soil tests. Eight Polled Hereford bulls were used during each of the 1994 to 1996 breeding periods. Thirteen different bulls were used throughout the study. Bulls were semen checked each year prior to the breeding period, and each breeding pasture was exposed to a minimum of two bulls. All bulls were used in all forage environments to preclude confounding sire effects with forage effects. Heifers were pregnancy checked in the fall each year.

Calves were born from late February through May in 1995, 1996, and 1997. Calves were weighed at birth and tagged. Bull calves were castrated at birth by banding. Calves were weaned at an average age of 205 days when full weights and hip heights were taken. Creep-feeding was not practiced. A description of production and management of the purebred and crossbred cows used in this study is given by Brown et al. (1993).

Individual heterosis was obtained as the difference between the means of traits reported for crossbred and purebred cows. Individual heterosis can be interpreted as the advantage in performance of crossbreds over purebreds. Maternal heterosis was obtained as the difference between means of traits reported for calves from crossbred dams and the means of traits reported for calves from purebred dams. Maternal heterosis is the advantage in performance that crossbred calves from crossbred dams have over crossbred calves from purebred dams. Maternal breed effects were obtained as the difference in trait means between reciprocal-cross cows. Generally, maternal breed effects can be interpreted as genetic effects in the dam expressed in her offspring. Grandmaternal breed effects were calculated as the difference in means of traits reported between calves of reciprocal-cross cows. Grandmaternal breed effects are genetic effects in the granddam expressed in her daughter's calves.

In the analysis of data, calving percentage and weaning weight per cow exposed for breeding were considered traits of the cow. Weaning traits of 205-day weight, hip height, weight:hip height ratio were considered traits of the calf. Data were analyzed by methods of mixed model least squares. The linear model for traits of the cow included effects for sire breed of cow, sire of cow in sire breed, dam breed of cow, forage, age of dam, and appropriate two- and three-factor interactions among the fixed effects where sire in sire breed was considered random and other effects fixed. The linear model for calf weaning traits included effects of sire of calf, sire breed of cow, dam breed of cow, forage, age of dam, sex of calf, and appropriate interactions among fixed effects where sire of calf was random and other effects fixed. Individual and maternal heterosis, maternal and grandmaternal breed effects, and interactions of these effects with forage effects were computed from linear contrasts of the least-squares means and tested using "t" statistics.

Results and Discussion

Calving Rate

Calving percentage per cow exposed for breeding is presented in Table 1 for each breed group and forage. Angus cows grazing BG and ROT were 36.6 and 38.3% higher in calving percentage per cow exposed than Angus cows grazing E+ ($P < .01$), respectively. The only other forage effect on calving percentage per cow exposed within breed was in A x B where cows on BG were 15% higher than cows on ROT ($P < .10$). Individual heterosis had a significant effect on calving percentage per cow exposed (29.6%, $P < .01$) for cows within the E+ forage base. Individual heterosis in calving percentage per cow exposed was nonsignificant on BG and ROT (9.5 and 2.6%, respectively). Brown et al. (1997) reported a 13.3% advantage for Angus on BG compared to Angus on E+ with individual heterosis in B x A crosses numerically larger on E+ compared to BG. There was evidence of interaction of maternal breed effects in favor of Brahman dams on BG and maternal breed effects in favor of Angus dams on ROT.

Weaning Traits

Least square means for 205-day weaning weight, weaning hip height, and weaning weight:hip height ratio are given in Table 2. Breed group and forage effects explained a significant ($P < .01$) amount of the variance in 205-day weaning weight. Additionally, there was evidence of substantial maternal heterosis for this trait ($P < .01$) with maternal heterosis for 205-day weight larger on E+ compared to BG ($P < .10$). There was little evidence of grandmaternal effects, but estimates favored the Angus granddams for this trait for calves on all forages. Brown et al. (1997) reported significantly greater maternal heterosis in 205-day weight in calves from Brahman and Angus crosses on E+ compared to BG. These data imply that crossbred cows and their calves were more tolerant of the negative effects of the tall fescue environment, whether managed all year or managed in a rotational scheme with BG.

Weaning hip height is a measure of long-bone growth in the calf, which is an indicator of potential slaughter weight/mature size and generally rate of maturing. Calves from A x

A cows on BG and ROT had greater mean hip height than those on E+ ($P < .05$); calves from A x B and B x A cows on ROT exceeded those on BG and E+ for mean weaning hip height ($P < .05$); and calves from B x B on ROT had higher mean hip height than those on BG ($P < .10$). Maternal heterosis for this trait was important ($P < .01$) for E+ and ROT; ($P < .10$) for BG, but greater on E+ and ROT than BG ($P < .01$). Grandmaternal effects were not evident on any forage. Brown et al. (1997) reported significantly greater maternal heterosis in hip height for calves from crosses of Brahman and Angus on E+ compared to BG.

Weaning weight to hip height ratio is calculated as a measure of body condition of the calf. For weaning weight to hip height ratio, calves from A x B, B x A, and B x B on BG exceeded contemporary calves from E+ and ROT ($P < .05$). Maternal heterosis for weight:height ratio was important ($P < .01$) and similar among forages. There was little evidence of grandmaternal effects for any forage. Estimates of maternal heterosis for this ratio for calves from Brahman and Angus crosses reported by Brown et al. (1997) were greater in calves managed on E+ than calves on BG.

Weaning Weight Per Cow Exposed

The combination of reproductive and maternal performance of the cow and growth of the calf is reflected in weaning weight per cow exposed (Table 3). Individual heterosis for this trait was important ($P < .01$) and was greater on E+ compared to BG and ROT ($P < .01$). On BG and ROT, crossbred cows weaned 98.6 and 112.2 lb ($P < .01$) more calf per cow exposed, respectively, compared to purebred cows while crossbred cows on E+ weaned 277.3 lb ($P < .01$) more calf per cow exposed compared to purebreds. Heterosis for 205-d weight per cow exposed reported by Brown et al. (1997) was numerically higher in Brahman-Angus crosses on E+ compared to contemporaries on BG.

General Discussion

These data show that crossbred cows and their crossbred calves were less susceptible to the detrimental effects of the E+ forage environment, regardless of whether they were managed all year on it or whether they were managed in a rotational grazing scheme involving E+ and BG. The resultant genetic effects from crossbreeding that made this possible were created by the planned matings of individuals in the breeds indicated. The degree of genetic effects created through gene combination value and perhaps some independent genes from a planned crossbreeding program are different from the degree of genetic effects created by commingling breeds. Breed complementarity also may have been involved in the tolerance of the crossbreds to E+. This would be particularly true if heat tolerance played an important role in producing these effects. However, if it were as simple as heat tolerance, then the B x B cattle should have performed more like the crossbreds. These results are applicable to the breeds, management, and specific and general environment reported in this study; however, there is nothing to indicate that other planned crosses of British and Brahman cattle would not give similar results under similar management.

Implications

It appears that the use of Brahman x Angus or Angus x Brahman crossbred cows bred to a bull of a third breed could be a beneficial management tool for producers faced with the management of E+. Rotating cows and calves from E+ to BG in the summer moderated some of the effects of E+ on calf growth but was not always comparable to BG. The rotation did appear to be more beneficial for purebred cows than crossbred cows, considering reproductive traits. Although this technology does not eliminate production losses attributable to E+, it appears to reduce these losses substantially. In combination with other technologies available for the management of endophyte-infected tall fescue, it may be possible to reduce losses to more acceptable levels.

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Table 1. Least-square means, individual heterosis, maternal breed effects and standard errors for calving rate (percentage) for cows from bermudagrass, tall fescue, and rotational forage environments.

Preweaning environment	Breed group[a]				Individual heterosis	Maternal breed effects
	A x A	A x B	B x A	B x B		
Bermudagrass	93.0 ± 6.5[b]	100.0 ± 6.0[f]	86.8 ± 6.0	75.2 ± 5.6[hi]	9.5 ± 5.9[d]	13.6 ± 8.5[f]
Tall fescue	56.4 ± 7.2[c]	93.2 ± 7.1[fg]	87.1 ± 6.5	64.7 ± 5.4[h]	29.6 ± 6.5[**e]	6.1 ± 9.6[fg]
Rotation	94.7 ± 5.5[b]	85.0 ± 5.2[g]	92.4 ± 5.7	77.6 ± 6.1[i]	2.6 ± 5.5[d]	-7.4 ± 7.7[g]

[a] A=Angus grandparent, B=Brahman grandparent, breed of grandsire listed first.
[**]*P* < .01 (H_0: individual heterosis or maternal breed effect = 0).
[b,c]Means in the same column with differing superscripts differ (*P* < .01).
[d,e]Means in the same column with differing superscripts differ (*P* < .05).
[f,g]Means in the same column with differing superscripts differ (*P* < .10).
[h,i]Means in the same column with differing superscripts differ (*P* = .11).

Table 2. Least-square means, maternal heterosis, grandmaternal breed effects, and standard errors for 205-day weaning weight, weaning hip height, weaning weight:hip height ratio for calves from bermudagrass, tall fescue, and rotational preweaning environments.

Preweaning Environment	Breed groups[a]				Maternal heterosis	Grandmaternal breed effects
	A x A	A x B	B x A	B x B		
Weaning weight (lb)						
Bermudagrass	489.2 ± 15.9[b]	551.4 ± 15.9[e]	577.2 ± 14.6[h]	549.6 ± 15.9[b]	45.0 ± 9.7[**h]	-25.8 ± 18.5
Tall fescue	371.1 ± 26.9[c]	500.0 ± 19.0[f]	510.1 ± 20.3[i]	491.9 ± 18.1[c]	70.5 ± 13.2[**i]	-9.9 ± 20.9
Rotation	436.3 ± 14.1[d]	542.1 ± 13.0[e]	547.8 ± 14.3[j]	528.6 ± 16.8[bc]	54.4 ± 9.5[**hi]	-5.1 ± 17.2
Weaning hip height (in)						
Bermudagrass	43.5 ± .5[e]	45.2 ± .5[e]	45.7 ± .5[e]	46.2 ± .5[h]	.6 ± .3[b]	-.5 ± .6
Tall fescue	41.3 ± .9[f]	45.8 ± .6[e]	45.6 ± .6[e]	46.4 ± .6[hi]	1.9 ± .4[**c]	.2 ± .7
Rotation	43.9 ± .4[e]	47.3 ± .4[f]	47.4 ± .5[f]	47.4 ± .6[i]	1.7 ± .3[**c]	-.2 ± .6
Weaning weight:hip height ratio (lb:in)						
Bermudagrass	2.01 ± .05[e]	2.17 ± .05[b]	2.25 ± .05[b]	2.12 ± .05[e]	.15 ± .03[**]	-.07 ± .06
Tall fescue	1.62 ± .09[f]	1.94 ± .06[c]	1.99 ± .06[c]	1.89 ± .06[f]	.21 ± .04[**]	-.04 ± .07
Rotation	1.77 ± .04[g]	2.04 ± .04[c]	2.06 ± .05[c]	1.98 ± .05[f]	.18 ± .03[**]	-.02 ± .05

[a]See Table 1.
[**]*P* < .01 (H_0:maternal heterosis or grandmaternal breed effects = 0).
[b,c,d]Trait means in the same column with differing superscripts differ (*P* < .01).
[e,f,g]Trait means in the same column with differing superscripts differ (*P* < .05).
[h,i,j]Trait means in the same column with differing superscripts differ (*P* < .10).

Table 3. Least-square means, individual heterosis, maternal breed effects and standard errors for weaning weight per cow exposed (lb)for cows from bermudagrass, tall fescue, and rotational forage environments.

Preweaning environment	Breed group[a]				Individual heterosis	Maternal breed effects
	A x A	A x B	B x A	B x B		
Bermudagrass	488.1 ± 44.1[b]	581.6 ± 41.5[f]	515.7 ± 39.9	412.4 ± 37.9[d]	98.6 ± 37.1[**b]	65.9 ± 57.5
Tall fescue	164.3 ± 51.6[c]	533.1 ± 48.3[fg]	486.9 ± 44.1	301.2 ± 43.2[e]	277.4 ± 43.2[**c]	46.3 ± 65.5
Rotation	405.5 ± 38.6[b]	502.9 ± 36.4[g]	532.6 ± 38.6	405.6 ± 41.3[d]	112.2 ± 34.6[**b]	-29.7 ± 53.2

[a] See Table 1.
[**]$P < .01$ (H_0: maternal heterosis or grandmaternal breed effect = 0).
[b,c]Means in the same column with differing superscripts differ ($P < .01$).
[d,e]Means in the same column with differing superscripts differ ($P < .05$).
[f,g]Means in the same column with differing superscripts differ ($P < .11$).

Postweaning Performance of Calves from Angus, Brahman, and Reciprocal-Cross Cows Grazing Endophyte-Infected Tall Fescue or Common Bermudagrass

Michael A. Brown[1], William A. Phillips[1], A. Hayden Brown, Jr.,[2] Samuel W. Coleman[1], Wesley G. Jackson[3], and James R. Miesner[3]

Story in Brief

Data from 403 Polled Hereford-sired calves from Angus, Brahman, and reciprocal-cross cows were used to evaluate the effects of preweaning forage environment on postweaning performance. Calves were spring-born in 1991 to 1994 and managed on either endophyte-infected tall fescue (E+) or common bermudagrass (BG) before weaning. After weaning, calves were shipped to the Grazinglands Research Laboratory, El Reno, Oklahoma, and assigned to one of two winter stocker treatments (winter wheat pasture or native range). Each stocker treatment was terminated in March, calves grazed cool-season grasses and were then moved to feedlot in June. In the feedlot, calves were fed to approximate .4 in fat over the 12th rib and averaged approximately 115 days on feed. When finished, calves were shipped to Amarillo, Texas, for slaughter. On average, calves from E+ gained faster as stockers ($P < .10$), had lighter starting and finished weights on feed ($P < .01$), lighter carcass weights ($P < .01$), and smaller longissimus muscles ($P < .05$) than calves from BG. Calves from E+ were similar to calves from BG in feedlot ADG, percentage kidney, heart and pelvic fat, fat thickness over 12th rib, yield grade, marbling score and dressing percentage. These data suggest that few carry-over effects from tall fescue preweaning environments exist, other than lighter, but acceptable weights through slaughter. These data further suggest that the tolerance to E+ in calves from reciprocal-cross cows, was also expressed postweaning.

Introduction

Millions of stocker calves are transported to the Southern Great Plains in the fall to background on wheat pasture or native range. Subsequent to the stocker phase, these calves are moved to feedlots in the High Plains, finished, and slaughtered to produce a significant portion of the nation's beef supply. Many of these calves are born and weaned on endophyte-infected tall fescue (**E+**). Preweaning performance of calves managed on E+ has been shown to be substantially lower than calves managed on other forages. However, there is little information on the existence or magnitude of any carry-over effects of E+ on calves weaned on this forage and transported to wheat pasture in the Southern Great Plains. Some evidence in the literature suggests the length of time required to recover from the effects of grazing E+ is difficult to predict. Consequently, the objective of this research was to compare the effects of preweaning forage environment on postweaning performance in calves weaned on common bermudagrass or endophyte-infected tall fescue.

Experimental Procedures

Data from 403 Polled Hereford-sired calves from Angus, Brahman, and reciprocal-cross cows were used to evaluate the effects of preweaning forage environment on postweaning performance. Calves were spring-born in 1991 to 1994 and managed on either endophyte-infected tall fescue or common bermudagrass (BG) before weaning. Calves were not creep-fed and bull calves were castrated at birth. Weights were taken at birth and weaning (ca. 205 days of age). Fifteen different sires were used over the four year study. Sires were replaced if injured or if they did not pass a breeding soundness exam and one or two sires were replaced each year.

Two weeks prior to weaning calves were vaccinated for IBR, PI_3, BVD, and clostridia species. After weaning calves were dry-lotted for 14 days and fed a weaning ration at 6 lb/hd/day and bermudagrass hay *ad libitum*. Calves were then shipped to the Grazinglands Research Laboratory, El Reno, Oklahoma, re-vaccinated consistent with preweaning

[1]USDA-ARS, Grazinglands Research Laboratory, El Reno, Oklahoma.
[2]Department of Animal Science, Fayetteville
[3]USDA-ARS Dale Bumpers Small Farms Research Center, Booneville

vaccines, implanted with Synovex®,and placed on a 13% CP receiving ration for a minimum of 14 days. After the receiving phase, calves were stratified to one of two winter stocker treatments by breed and preweaning forage where stocker treatments were wheat pasture (WW) or native range plus CP supplementation (NR) (November to mid-March). Calves on NR were fed between .8 and 1.0 lb of CP per head per day based on body weight with the goal of realizing approximately .45 lb/day gain in the calves. During the spring period (mid-March to early June) all calves grazed cool-season grasses (Bromus spp.) on dormant warm season native grass pastures. Individual weights were taken at the beginning, middle, and end of the stocker phase and ADG calculated. In early June, calves entered the feedlot.

In the feedlot, calves were blocked by sex and stratified within sex by breed, preweaning treatment, and stocker management. Within each stratum, calves were randomly assigned to pens for finishing. Calves were treated for internal parasites with Ivomec®, and implanted with Synovex® at the beginning of the feedlot phase. Calves were transitioned to the finishing ration by decreasing the hay content of the diet approximately 9% (DM basis) weekly for 4 weeks. Calves had *ad libitum* access to the finishing diet and were considered finished when fat thickness over the 12th rib was ≥ .4 in as determined by ultrasonography. Ultrasounds were done starting on 100 days on feed and on 14-day intervals thereafter. When finished, calves were weighed and shipped to Amarillo, Texas, for slaughter. Hot carcass weight, longissimus muscle, fat thickness over the 12th rib, marbling score, percentage kidney, heart, and pelvic fat (KHP), yield grade, and dressing percentage were measured or calculated. All experimental procedures used were approved by the Animal Care Committee of the Grazinglands Research Laboratory.

Data were analyzed by methods of weighted least squares. Analyses accounted for years, sire of calf, grandsire breed, grandam breed, preweaning forage, postweaning forage, age of dam, sex of calf, and all possible interactions among fixed effects, where sire of calf was a random effect and all other effects were fixed. Tests of hypotheses were performed using F and t statistics.

Results and Discussion

Stocker Gains

Least squares means and associated standard errors for weaning weights and postweaning stocker ADG are given in Table 1. Tall fescue reduced weaning weights by an average of 82 lb ($P < .01$) but had more effect on calves from purebred cows compared to calves from crossbred cows. Calves from the E+ preweaning environment gained faster than calves from the BG preweaning environment ($P < .01$) in the winter stocker period. However, during the spring stocker period, there was little evidence of preweaning forage differences. Combining both periods (winter and spring), calves from the E+ preweaning environment gained faster than calves from BG ($P < .10$). The 50% Brahman F_1 calves from both preweaning environments performed similarly and better than other breed groups with no suggestion of cold intolerance to the postweaning environment of the western Oklahoma winter.

Feedlot Traits

Least squares means and associated standard errors for feedlot weights and gains are given in Table 2. Starting weights were lower in calves from the E+ preweaning environment compared to calves from BG ($P < .01$) consistent with their differences in weaning weights (Brown et al., 1997). Similarly, finished weights in calves from the E+ preweaning forage were lower ($P < .01$) than calves from BG. There was not strong evidence that feedlot ADG differed between preweaning forages. Overall, calves from E+ gained .13 lb/day less than calves from BG ($P > .25$).

Preweaning environment had little impact on starting weight in calves from A x B and B x A cows whereas preweaning forage effects were large in calves from purebred cows ($P < .01$). These initial weight differences carried over to finished weight so that differences between calves from crossbred and purebred cows on E+ was larger than a similar comparison on BG. There was a trend for feedlot ADG to be inversely proportional to percentage Brahman in these data.

Carcass Traits

Least squares means and associated standard errors for carcass traits are given in Table 3. Averaged over breed groups, hot carcass weights averaged 37 lb lower ($P < .01$) in calves from E+ compared to calves from BG and mean longissimus muscle was smaller in calves from E+ ($P < .01$). There was little evidence of preweaning forage effects on kidney, heart, and pelvic fat, fat thickness over the 12th rib, yield grade, marbling score, percentage grading choice**,** or dressing percentage when averaged over breed group. Similar to live weights, there was a trend for carcass weight and longissimus muscle area differences between calves from crossbred and purebred cows to be larger on E+ compared to BG. Calves from crossbred cows had 21% fewer ($P < .01$) that graded choice than calves from purebreds on E+ whereas there was only a 1% ($P > .80$) difference in a similar comparison in calves from BG. There were also trends for fat thickness, yield grade, and marbling score to decrease with increasing percentages of Brahman breeding.

General Discussion

These results demonstrated a small advantage in gain in stocker cattle from an E+ preweaning environment compared to BG and similar gains for the preweaning environments during the spring grazing and feedlot phase. Thus, averaged over breed groups, calves from the E+ preweaning environment started at a lighter weight, gained about the same through slaughter compared to calves from the BG preweaning forage environment, and finished at a lighter weight when fat thickness was used as the endpoint. There was no substantial indication that the E+ preweaning environment negatively affected carcass quality, and there were no discounts

received for light carcasses in these cattle with only one carcass not exceeding 525 lb. Therefore, it is reasonable to conclude from these data that there was no discernable negative impact of a preweaning endophyte-infected tall fescue environment on postweaning performance or carcass traits. Moreover, fewer differences in weights between calves from the two preweaning forages occurred in calves from crossbred cows compared to similar comparisons in calves from purebred cows. There were similar trends in hot carcass weight and longissimus muscle. Consequently, there were even fewer effects of E+ on calves from crossbred cows in the postweaning period, and a level of preweaning E+ tolerance reported in three-breed cross calves from Brahman-Angus dams (Brown et al., 1997) seems to continue during the postweaning phase. However, these conclusions may differ for fall-born calves from E+ where these calves are weaned in the spring and are placed into stocker or feeder programs in the summer directly from E+.

There were trends in these data consistent with other hypotheses concerning Brahman cattle, namely, performance as stockers was directly proportional to percentage Brahman while feedlot performance and marbling score were inversely proportional to percentage Brahman.

Implications

Preweaning management of calves on endophyte-infected tall fescue may decrease weaning weights and part of this reduction in weight may carry through to slaughter. However, there are few other indications of postweaning carry-over effects for calves managed on endophyte-infected tall fescue. Moreover, in cattle tolerant of endophyte-infected tall fescue during the preweaning phase, such as calves from Brahman-Angus cross cows, preweaning advantages in weight are reflected during the postweaning phase. Therefore, in spring-born calves, there do not appear to be substantial reasons to place a price discount on cattle weaned on endophyte-infected tall fescue.

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Table 1. Least-square means and standard errors for 205-day weight (lb) and stocker ADG (lb/day) for calves from bermudagrass and tall fescue preweaning environments

Trait	Preweaning environment	Breed group[a] A x A	A x B	B x A	B x B	Avg
205-day	Bermudagrass	501.8 ± 6.8	561.9 ± 6.8	590.8 ± 7.1	577.6 ± 7.9	558.0 ± 4.2
Weight	Tall Fescue	391.5 ± 7.7	506.6 ± 7.7	516.8 ± 8.6	489.9 ± 9.5	476.2 ± 8.2
	BG vs. E+	*P* < .01	*P* < .01	*P* < .01	*P* < .01	*P* < .01
Winter	Bermudagrass	.82 ± .04	.71 ± .04	.71 ± .04	.97 ± .02	.79 ± .02
ADG	Tall fescue	.93 ± .04	.73 ± .04	.97 ± .07	1.04 ± .04	.90 ± .02
	BG vs. E+	*P* < .13	NS[b]	*P* < .01	NS	*P* < .01
Spring	Bermudagrass	1.74 ± .07	1.94 ± .07	1.94 ± .09	2.18 ± .09	1.96 ± .04
ADG	Tall Fescue	1.72 ± .09	1.90 ± .09	1.98 ± .09	2.27 ± .11	1.96 ± .04
	BG vs. E+	NS	NS	NS	NS	NS
Total	Bermudagrass	1.15 ± .04	1.12 ± .04	1.17 ± .04	1.43 ± .04	1.21 ± .02
ADG	Tall Fescue	1.21 ± .04	1.15 ± .04	1.32 ± .04	1.43 ± .07	1.28 ± .02
	BG vs. E+	NS	NS	*P* < .05	NS	*P* < .10

[a] A = Angus grandparent, B = Brahman grandparent, breed of grandsire listed first.
[b] NS = not significant.

Table 2. Least-square means and standard errors for feedlot traits for calves from bermudagrass and tall fescue preweaning environments.

Feeddlot trait[b]	Preweaning environment	Breed group[a] A x A	A x B	B x A	B x B	Avg
IWT	Bermudagrass	758 ± 13	809 ± 15	829 ± 15	851 ± 15	811 ± 9
	Tall fescue	686 ± 13	796 ± 15	816 ± 15	756 ± 20	763 ± 9
	BG vs. E+	*P* < .01	NS[c]	NS	*P* < .01	*P* < .01
FWT	Bermudagrass	1162± 18	1188 ± 20	1210 ± 20	1188 ± 20	1186 ± 11
	Tall Fescue	1067± 18	1168 ± 20	1146 ± 22	1098 ± 29	1120 ± 11
	BG vs. E+	*P* < .01	NS	*P* < .05	*P* < .05	*P* < .01
ADG	Bermudagrass	3.46± .11	3.28 ± .13	3.28 ± .13	3.00 ± .13	3.26 ± .07
	Tall Fescue	3.30± .11	3.28 ± .13	3.00 ± .13	2.95 ± .18	3.13 ± .09
	BG vs. E+	NS	NS	*P* < .13	NS	NS

[a] A=Angus grandparent, B=Brahman grandparent, breed of grandsire listed first.
[b]IWT=Initial weight, lb; FWT=Final weight, lb; ADG=Average daily gain, lb/day.
[c] NS = not significant.

Table 3. Least-square means and standard errors for carcass traits for calves from bermudagrass and tall fescue preweaning environments.

Carcass trait[b]	Preweaning environment	Breed group[a] A x A	A x B	B x A	B x B	Avg
HCW	Bermudagrass	714 ± 9	732 ± 9	765 ± 11	736 ± 13	736 ± 7
	Tall fescue	648 ± 11	708 ± 11	736 ± 13	701 ± 13	699 ± 7
	BG vs. E+	*P* < .01	*P* < .10	*P* < .10	*P* < .10	*P* < .01
REA	Bermudagrass	12.9± .2	13.2 ± .2	13.3 ± .2	13.1 ± .2	13.1 ± .1
	Tall Fescue	12.1± .2	13.1 ± .2	12.9 ± .2	12.7 ± .3	12.7 ± .1
	BG vs. E+	*P* < .01	NS[c]	NS	NS	*P* < .01
KHP	Bermudagrass	2.34± .04	2.28 ± .04	2.24 ± .04	2.27 ± .05	2.28 ± .02
	Tall Fescue	2.31± .05	2.26 ± .05	2.33 ± .05	2.28 ± .06	2.30 ± .02
	BG vs. E+	NS	NS	NS	NS	NS
FAT	Bermudagrass	.52± .02	.52 ± .02	.48 ± .02	.41 ± .03	.48 ± .02
	Tall Fescue	.46± .03	.46 ± .03	.48 ± .03	.43 ± .03	.46 ± .02
	BG vs. E+	NS	NS	NS	NS	NS
YG	Bermudagrass	2.87 ± .10	2.82 ± .10	2.77 ± .10	2.59 ± .12	2.76 ± .06
	Tall Fescue	2.72 ± .11	2.65 ± .11	2.83 ± .12	2.67 ± .14	2.72 ± .06
	BG vs. E+	NS	NS	NS	NS	NS
MARB	Bermudagrass	3.98 ± .07	3.71 ± .07	3.74 ± .08	3.42 ± .09	3.71 ± .04
	Tall Fescue	4.00 ± .09	3.54 ± .08	3.65 ± .09	3.59 ± .10	3.69 ± .05
	BG vs. E+	NS	NS	NS	NS	NS
DP	Bermudagrass	61.79 ± .27	62.41 ± .27	61.77 ± .29	61.61 ± .34	61.89 ± .16
	Tall Fescue	61.09 ± .32	62.08 ± .31	62.08 ± .35	61.47 ± .39	61.68 ± .18
	BG vs. E+	*P* < .10	NS	NS	NS	NS
% CH	Bermudagrass	46.80 ± .06	21.29 ± .06	30.92 ± .07	7.45 ± .07	26.62 ± .04
	Tall Fescue	61.17 ± .07	14.05 ± .31	17.05 ± .08	12.10 ± .09	26.09 ± .04
	BG vs. E+	NS	NS	NS	NS	NS

[a] A=Angus grandparent, B=Brahman grandparent, breed of grandsire listed first.
[b]HCW=hot carcass wt., lb; REA=longissimus muscle, in^2; KHP=kidney, heart, pelvic fat, %; FAT=fat thickness over, 12th rib, in; % CH= % Choice; YG=yield grade; MARB=marbling score (min. slight=3, min. small=4); DP=dressing percentage, %.
[c] NS=not significant.

Body Measurements as Tools for Prediction of a Heifer's Probability of Calving

C.F. Rosenkrans, Jr.,[1] A.H. Brown, Jr.,[1] and Z.B. Johnson[1]

Story in Brief

Our objective was to determine if physical characteristics of heifers at weaning, and(or) as yearlings could be used to select heifers that would calve as two-year olds. Data were collected on developing purebred Angus (n = 88), Charolais (n = 24), Hereford (n = 41), and Red Poll (n = 28) heifers. Each year (n = 3) heifers were developed as contemporaries. At weaning and yearling the weight (WT), hip height (HH) and width (HW), and pelvic height (PH) and width (PW) were determined. Logistic regression analyses were used to determine which traits were related to the probability of a heifer calving at two years of age. Heifers were categorized based on calving status, No (heifer did not calve as a two-year-old) or Yes (heifer calved between 22 and 27 months of age). Average values for the physical characteristics (WT, HH, HW, PH, and PW) of the two heifer groups did not differ at weaning or as yearlings. Based on the logistic regression, heifer age and PW at weaning and HW as yearlings were important ($P < .05$) sources of variation influencing her probability of calving as a two-year-old. For each day older at weaning, and each 1 inch increase in PW at weaning one would expect a 1.03 and 3.08 increase in the odds of calving as a two-year-old, respectively. For each 1 inch increase in yearling HW the odds of calving as a two-year-old increased with an odds ratio of 1.36 to one. In conclusion, these data suggest that age and pelvic width at weaning, and hip width at yearling may be useful in selecting replacement heifers.

Introduction

Selecting replacement heifers for cow-calf producers is very critical for production efficiency. Unlike growth traits, reproductive traits have low coefficients of heritability resulting in slow and inefficient selection criteria. Therefore, if reliable indicators of reproductive success were available, herd reproduction might be improved by indirect selection. Producers have traditionally used a variety of methods for selecting replacement heifers. Those schemes have included physical measures such as weight and body condition score; physiological indicators such as blood constituents and progesterone concentrations and (or) estrous detection; and molecular/genetic markers such as have been developed for swine and sheep. Research has shown that heifers that attain puberty early tend to breed earlier and are more reproductively sound over their lifetime. Our objective was to determine if physical characteristics at weaning and yearling could be used to determine the probability of heifers calving at two years of age.

Materials and Methods

Data were collected from three consecutive years on developing Angus (n = 88), Charolais (n = 24), Hereford (n = 41), and Red Poll (n = 28) heifers at the Arkansas Agricultural Experiment Station, Fayetteville. Heifers were born in the spring and weaned in the fall of the year. After weaning, heifers were developed as contemporaries on common bermudagrass (*Cynodon dactylon*) and tall fescue (*Festuca arundinacea*) which were over-seeded with winter annuals of wheat (*Triticum acstiuum*) and red clover (*Trifolium pratence*). In addition to pasture, heifers received a daily supplement consisting of cracked corn, soybean meal, vitamins (A, B, and E), limestone, and molasses. Average daily supplement on pasture from weaning (7 months of age) to breeding (14 to 15 months of age) was .37% $BW^{.75}$. Stocking rate on pasture was low (one heifer per acre) and daily feed was allocated when all heifers were present at the feed bunk and each heifer had 2 feet of linear bunk space.

Physical measurements of these heifers were determined at weaning (approximately 7 months of age, range 195 to 287 d) and yearling (approximately 11 mo of age, range 280 to 399 d). Body weight (WT) was recorded. Pelvic height (PH) and width (PW) were measured per rectum using a Rice Pelvimeter. Body height (HH) and width (HW) at hips were measured using a sliding caliper developed specifically to measure external body dimensions in beef cattle.

Logistic regression analyses were used to determine which traits were related to a heifer's probability of calving as a two-year-old. Logistic regression is a form of statistical modeling that is often appropriate for categorical data (for

[1] All authors are associated with the Department of Animal Science, Fayetteville.

instance: Did a heifer calve? (Yes or No). That type of analysis describes the relationship between a categorical response variable and a set of explanatory variables (in this case, age, WT, HH, HW, PH, and PW). The generated coefficients are similar to those obtained with multiple-regression analyses. Results are usually presented as an odds ratio which indicates the amount that a one unit increase (or decrease) in an explanatory variable increases (or decreases) the odds of a response in the categorical variable. In addition to the odds ratio, logistic regression generates parameter estimates that can be used to predict an animal response (in this case calving as a two-year-old).

Results and Discussion

Table 1 presents the means by calving group (Yes vs. No) for the explanatory variables evaluated in this experiment. While the heifers that did not calve had numerically lower weights and usually smaller body measurements than those heifers that calved, the values were not statistically different. Those findings indicate that individual measurements alone would not have been useful in predicting which heifers should calve as a two-year-old.

Results of the logistic regression analysis are shown in Table 2. The explanatory variables retained in the model met the entry level of $P < .15$ and entered the model in a forward selection manner. Three variables were retained in this model; heifer age and pelvic width at weaning, and hip width as a yearling. Using the parameter estimates of Table 2, one can predict the probability of an individual heifer calving (see Table 3).

A general philosophy concerning replacement heifers is to select heifers on growth rates and weight; however, that management practice can result in sustainability problems. Previous work has shown that one can select for increased pelvic area without increasing hip height or body weight, which should result in increased sustainability of the cow-calf operation. Our data suggest that pelvic width coupled with heifer age and hip width may be used as an early predictor of a heifer's potential as a replacement cow. That information used with more traditional selection criteria could increase overall profitability of the cow-calf operation.

Implications

These data suggest that age at weaning is an important trait in determining whether a heifer will calve as a two-year-old. Also that various body measurements at weaning or yearling, particularly pelvic and hip width may be useful in selecting replacement heifers.

Table 1. Means for explanatory variables by calving status[1].

	Calved at two years of age			
	No		Yes	
Explanatory variable	Mean	SE	Mean	SE
At weaning				
Age, days	237.	19.1	247.4	17.9
Weight, lb	395.6	56.5	418.7	63.4
Hip height, in	40.4	2.6	40.9	2.4
Hip width, in	12.7	1.4	13.3	1.3
Pelvic height, in	3.99	.75	3.94	.83
Pelvic width, in	3.47	.38	3.73	.48
At yearling				
Age, days	334.2	26.	343.4	22.2
Weight, lb	512.8	68.5	539.5	75.2
Hip height, in	43.5	2.5	44.3	2.6
Hip width, in	13.3	.9	13.7	1.
Pelvic height, in	4.44	.65	4.36	.73
Pelvic width, in	4.11	.31	4.3	.44

[1] Data were collected on 181 purebred beef heifers, of which 66 did not calve as a two-year-old. Heifers (n = 115) calving as two-year-olds averaged 24.7 months of age at calving with a range in age of 22 to 27 months.

Table 2. Results of logistic regression analysis[1] using weaning and yearling data.

Explanatory variable	DF	Parameter estimate	Odds ratio
Intercept	1	-15.5349	
Weaning			
Age, d	1	.0329	1.033
Pelvic width, in	1	1.1239	3.077
Yearling			
Hip width, in	1	.3094	1.363

[1]Reduced model using forward selection. Explanatory variables of Table 1 entered the model one at a time starting with the variable with the largest chi-squared statistic. Variables continued to enter the model as long as the variable was significant for the specified level for entry. In this analysis that was 0.15. Once a variable entered the model it was not removed.

Table 3. Probability[1] of a heifer calving at two years of age using combinations of age and pelvic width at weaning and hip width at yearling.

Age, days	200			240			260		
Hip width, in	12	13	14	12	13	14	12	13	14
Pelvic width									
3.0	.13	.17	.22	.36	.44	.51	.53	.60	.67
3.2	.16	.21	.26	.42	.49	.57	.58	.65	.72
3.4	.19	.25	.31	14	.55	.63	.63	.70	.76
3.6	.23	.29	.36	.53	.61	.68	.69	.75	.80
3.8	.27	.34	.41	.59	.66	.72	.73	.79	.84
4.0	.32	.39	.47	.64	.71	.77	.77	.82	.86
4.2	.37	.45	.52	.68	.75	.80	.81	.85	.89
4.4	.43	.50	.58	.73	.79	.84	.84	.88	.91
4.6	.48	.56	.63	.78	.83	.87	.87	.90	.93
4.8	.53	.61	.68	.81	.86	.89	.89	.92	.94
5.0	.59	.67	.73	.84	.88	.91	.91	.93	.95

[1]Probabilities were calculated using the parameter estimates of Table 2 and the following formula.

$$\Pr(\text{calving}) = \frac{e^{-15.5349 + .0329*(\text{weaning age}) + 1.1239*(\text{pelvic width at weaning}) + .3094*(\text{hip width at yearling})}}{1 + e^{-15.5349 + .0329*(\text{weaning age}) + 1.1239*(\text{pelvic width at weaning}) + .3094*(\text{hip width at yearling})}}$$

Evaluation of Hospital Treatment Regimens for the University of Arkansas Beef Research Facility at Savoy

Sharon Copeland, Dianne H. Hellwig, Elizabeth B. Kegley, Zelpha B. Johnson, and Suzanne Krumpleman[1]

Story in Brief

Bovine respiratory disease (BRD) is a complex, economically important disease of stocker and feedlot cattle. Stress from shipping and co-mingling of cattle at livestock auctions predispose cattle to BRD ("shipping fever"). There are several respiratory viruses involved, which predispose the animal to secondary bacterial infections. The prevention of BRD involves vaccinations and minimizing animal stress. In the past few years, the use of antibiotics to mass medicate cattle that are at high risk for shipping fever has become commonplace. Concern has arisen that the bacteria involved will develop resistance to these antibiotics. The University of Arkansas Beef Research Unit has begun to notice a lack of clinical response with tilmicosin (Micotil®, Elanco Animal Health, Indianapolis, Indiana). This study was conducted to compare the efficacy of using tilmicosin vs. florfenicol (Nuflor® Schering-Plough Animal Health, Union, New Jersey) for the initial treatment of BRD. Bacterial nasal cultures were obtained from the cattle each time they were treated for BRD. These cultures were examined for pathogens of respiratory significance and the possible development of antimicrobial resistance. Nineteen percent of both species of *Pasteurella* isolated were resistant to tilmicosin. All of the respiratory isolates were susceptible to florfenicol.

Introduction

Bovine respiratory disease (BRD) complex is the most economically important infectious disease of weaned calves and feedlot cattle (Morck et al., 1993). Pathogenic microorganisms and various stressors, such as shipping over long distances and co-mingling with multi-source cattle, predispose cattle to BRD. Producers commonly refer to BRD as "shipping fever."

Several viruses "set the stage" for BRD; however, three bacteria appear to be of major importance in the pathogenesis of this disease complex; *Pasteurella haemolytica, Pasteurella multocida,* and *Haemophilus somnus* (Andrews and Kennedy, 1997). Consistent isolation of *P. haemolytica* has lead to the consensus that it is the most important bacterial component of BRD(Confer et al., 1988). Conversely, *P. multocida* could be important in some outbreaks of stocker and feedlot respiratory disease (Allen et al., 1991). Its importance as a major respiratory pathogen is underemphasized. Many producers use a mass medication arrival program for cattle that are considered to be at high risk for BRD. There is concern that frequent and widespread usage of antimicrobials will result in the development of resistant strains of bacteria.

The Beef Research Unit at Savoy has increasingly noted a lack of clinical response with tilmicosin (D.H. Hellwig, personal communication). To determine the extent of this resistance, a study was conducted to compare tilmicosin with florfenicol as the initial antimicrobial used for treating respiratory disease.

Experimental Procedures

The study consisted of 96 bull stocker calves (approximately 500 lb) that were shipped to the Savoy facility from a salebarn in central Arkansas. Upon arrival calves were weighed, identified with ear tags, and randomized into one of two treatment groups. Forty-eight hours after arrival, calves were vaccinated with a modified-live vaccine which included Infectious bovine rhinotracheitis (IBR), Parainfluenza virus$_3$ (PI_3), Bovine viral diarrhea virus (BVDV), and Bovine respiratory syncycial virus (BRSV). Calves were also given vaccinations for *Pasteurella sp., Haemophilus somnus* and *Clostridium sp.* ("Blackleg"). The calves were de-wormed and horns were tipped. Two weeks after initial vaccination viral and bacterial boosters were given, calves were branded, and bulls were castrated by banding. Six calves were placed in one of 16 randomized pens designated as either treatment 1 or treatment 2. Calves were housed in dry lots and fed a total mixed ration (Table 1). Calves in treatment 1 were treated with tilmicosin (according to label directions) when signs of BRD were first noted. Calves in treatment 2 were

[1]All authors are associated with the Department of Animal Science, Fayetteville

treated with florfenicol. Subsequent treatments due to relapse consisted of ceftiofur (Naxcel®, Pharmacia & Upjohn Animal Health, Kalamazoo, Michigan) on the first relapse and spectinomycin (Pharmacia & Uphohn Animal Health, Kalamazoo, Michigan) for the second relapse. No further treatments after the second relapse were administered. The criteria for BRD treatment included nasal/ocular discharge, depression, lack of appetite, and coughing. Calves with rectal temperatures of equal to or above 104°F. were treated with the designated antimicrobial. Animals were treated and placed in hospital pens, re-evaluated in 48 hours, and returned to their home pen if the rectal body temperature had fallen below 104°F accompanied by improvement of clinical signs. Bacterial nasal cultures were collected by cleaning the excess mucus discharge from one nostril and inserting a culture swab into the nasal cavity. Swabs were taken at the first treatment and at first and second relapses. Bacterial cultures were not obtained beyond the third treatment for BRD. The samples were taken to the Arkansas Poultry and Livestock Commission Diagnostic Laboratory in Springdale, Arkansas. Specific bacteria of interest were *P. haemolytica, P. multocida* and *Haemophilus somnus.* Antibiotic sensitivities to tilmicosin and florfenicol were determined using the Kirby-Bauer disc diffusion method (Bauer et al., 1966).

Results and Discussion

There were no statistical differences between treatment 1 and treatment 2 for any of the parameters examined (Table 2). Nearly 56% (55.8%) of the tilmicosin-treated calves and 40.3% of the florfenicol-treated calves relapsed once (P = .18). The percentage of calves relapsing a second time was 7.5% and 11% for tilmicosin and florfenicol, respectively (P = .67). The average medication costs per head for tilmicosin vs. florfenicol was $14.79 and $17.84, respectively. Average daily gain (lb/head/day) and the cost of gain for the tilmicosin vs. florfenicol groups was 2.21 vs. 2.36 pounds (P = .29) and $ .69 vs $ .68 (P = .82) respectively. Finally, the average feed to gain ratio for the tilmicosin vs. florfenicol group was 6.21 vs. 6.05 (P = .55), respectively.

There were 31 *P. multocida,* 25 *P. haemolytica*, and 5 *Haemophilus somnus* isolates cultured. Forty-seven of the *Pasteurella sp.* isolates were tested for antimicrobial sensitivity to tilmicosin and florfenicol (Table 3). Nineteen percent (9/47) of the *Pasteurella sp.* isolated were resistant to tilmicosin and 21% (10/47) were resistant to oxytetracycline. All of the isolates were sensitive to florfenicol. Isolates resistant to tilmicosin were sent to Elanco Animal Health, Indianapolis, IN for further evaluation of the resistance patterns. Minimum inhibitory concentrations (MIC) were determined by Elanco. These isolates were determined to be sensitive using this procedure.

For this group of calves, there was no difference between tilmicosin and florfenicol with regard to the number of relapses or performance parameters. Calves in both treatments experienced high morbidity and spent time in the hospital for further treatments.

There have been reports that florfenicol can depress feed intake. This was not found to be the case in this study, as the florfenicol calves had a higher average daily gain. The higher medication costs for florfenicol in this study is a reflection of the higher cost of the drug and not the frequency of its use.

Concerns have arisen that the pathogens associated with respiratory illness are developing resistance to tilmicosin. This study indicated that there are a small percentage of tilmicosin-resistant *Pasteurella* isolates, determined with the Kirby-Bauer procedure. The laboratory at Elanco Animal Health reported that the isolates that were sent to their laboratory were considered to be sensitive to tilmicosin using the MIC method. Laboratory (*in vitro)* sensitivities do not necessarily reflect what is happening in the animal (*in vivo).* The sensitivity test is used as a guideline to choose the appropriate antimicrobial, but should be used in conjunction with sound clinical judgement. In this study, there was a lack of clinical response in the cattle from which tilmicosin-resistant *Pasteurella* were isolated. In addition, presence of resistant isolates within a group of animals can cause problems. These isolates may circulate through the group, making antimicrobial therapy more difficult and decreasing the production efficiency of the group.

There are additional reasons why antimicrobial treatment would appear to be ineffective. It should be pointed out that conditions at the beginning of the study were harsh. The weather was both cold and wet when the calves were shipped and processed. The vaccinations administered at the beginning of the study may not have worked as effectively due to the stressful conditions under which the calves were processed. The lack of clinical response to either of the antimicrobials used may be due to the overwhelming pathogen load, preventing the antimicrobial from working at its maximum potential.

Implications

The lack of response to tilmicosin seen in this study may be due to antimicrobial resistance or exposure to a large number of respiratory pathogens under highly stressful conditions. Careful consideration should be given when deciding which antimicrobial to use and whether or not a mass treatment program is warranted, in order to avoid the development of resistant respiratory pathogens.

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Table 1. Ration.

Ingredient	%
Corn, cracked	53.42
Cottonseed hulls	30
Soybean meal	11
Molasses, blend of cane and beet	4.1
Dicalcium phosphate	0.4
Limestone	0.85
Salt, white	0.15
Vitamin premix[a]	0.075
Trace mineral premix[b]	+
Bovatec[c]	+

[a] Vitamin premix provided 4,400 IU vitamin A, 880 IU vitamin D, and 11.6 IU vitamin E/kg of ration
[b] Trace mineral premix added 26 mg zinc and 0.1mg selenium/kg of ration
[c] Added to provide 33.6 mg lasalocid/kg ration

Table 2. Comparison of mean values (± SE) for calves treated with tilmicosin[a] or florfenicol[b].

Treatment	1st Relapse (%)	2nd Relapse (%)	Medication Cost ($/head)	Cost of Gain ($/head)	Feed:Gain (lb feed/ lb gain)	ADG (lb/head/d)
Tilmicosin	55.8 ± 3.0	7.5 ± 6.0	14.79 ± 1.08	.69 ± .11	6.2 ± 0.2	2.2 ± 0.2
Florfenicol	40.3 ± 3.5	11.0 ± 4.9	17.84 ± 9.02	.68 ± .11	6.1 ± 0.1	2.4 ± 0.2

[a] Micotil®, Elanco Animal Health, Indianapolis, Indiana
[b] Nuflor®, Schering-Plough Animal Health, Union, New Jersey

Table 3. Resistant and susceptible strains of bacterial isolates to tilmicosin and florfenicol[a].

Bacteria[b] (no. isolates)	Tilmicosin		Florfenicol	
	R[b]	S[b]	R	S
P. haemolytica (20)	6	14	0	20
P. multocida (27)[c]	3	24	0	27
H. somnus (5)	0	5	0	5

[a] Sensitivity determined using the Kirby-Bauer method. Only bacterial isolates of respiratory significance were examined for antimicrobial sensitivity.
[b] R = resistant, S = susceptible.
[c] Two isolates had intermediate sensitivity to tilmicosin.

Reduction of *E. coli* and *Salmonella typhimurium* in Ground Beef Utilizing Antimicrobial Treatments Prior to Grinding[1]

Fred W. Pohlman[2], Matt R. Stivarius[2], Kathy S. McElyea[2], Jason K. Apple[2], Michael G. Johnson[3], and Amy L. Waldroup[4]

Story in Brief

The objective of this study was to determine the impact of different antimicrobial treatments and vacuum technology on the reduction of microflora in ground beef. Beef trimmings from mature cows were frozen at –20˚C, thawed to 4˚C and inoculated with *E. coli* (11775 ATCC) and *Salmonella typhimurium* (Nalidixic acid resistant). The trimmings were mixed with antimicrobial treatments by vacuum tumbling or aerobic tumbling for 3 minutes. Specific antimicrobial treatments evaluated were a control, 5% lactic acid, hot water (82.2 ºC), 10% trisodium phosphate (TSP) and .5% cetylperidinium chloride (CPC). Beef trimmings were then twice ground through a 1/8-inch plate, aerobically packaged and displayed in simulated retail storage for seven days. Samples were evaluated on days 0, 1, 2, 3, and 7 for aerobic, *E. coli*, *Salmonella* and coliform counts. Lactic acid, CPC, and TSP were effective at reducing *E. coli*, coliform and aerobic plate counts through seven days of storage. Likewise, CPC and TSP reduced *Salmonella* counts through storage. There was no difference in the vacuum vs. aerobic treatments for microbial data. Therefore, use of cetylpyridinium chloride or trisodium phosphate prior to grinding may provide an inhibition for the outgrowth of *E. coli* and *Salmonella* in ground beef during refrigerated storage.

Introduction

Food safety is an issue important to consumers as well as the animal/meat industry. Outbreaks of food borne illnesses associated with meat and corresponding product recalls have caused lost revenue for processors and have negatively affected consumer perception of beef. Two microorganisms associated with food borne illness in fresh meat, particularly ground beef, have been pathogenic *E. coli* and *Salmonella*. While a number of technologies have been investigated for decontaminating beef carcasses (Gorman et al., 1995; Prasai et al., 1991; and Phebus et al., 1997), concern still exists with regard to microbial populations on finished products. Although the beef industry has embraced technologies such as steam pasteurization and organic acid rinses for decontaminating beef carcasses, there is a need for microbial interventions near the end of the ground beef production system. Most technologies investigated thus far have targeted microorganisms attached to the surface of the carcass. Unfortunately, microorganisms that have penetrated to subsurface levels may be afforded greater protection against antimicrobial treatments. Therefore, the objective of this research was to evaluate the impact of microbial interventions and vacuum technology to decontaminate surface and subsurface microorganisms prior to grinding and packaging on ground beef preservation and shelf life.

Experimental Procedures

Boneless, frozen cow beef trim (–20 ˚C) was thawed to 4˚C and inoculated with a nalidixic acid resistant *Salmonella typhimurium* and *E. coli* (ATCC #11775). Innoculums were prepared from frozen (-80˚C) stock cultures that were maintained by brain heart infusion (BHI) broth with glycerol (20%). Frozen cultures of *Salmonella typhimurium* and *E. coli* (ATCC #11775) were thawed and .1 ml of each culture were inoculated into separate 40 ml aliquots of BHI broth for 24 hours. Bacteria were harvested by centrifugation (4000g x 20 minutes @ 37˚C), re-suspended in the same volume of .1% peptone water and pooled together to make a bacterial cocktail. The cocktail was cooled to a temperature of 4 ˚C and combined with the meat and allowed to attach for 1 hour. Meat samples were then drained and separated into

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[2] Department of Animal Science, Fayetteville.
[3] Department of Food Science, Fayetteville.
[4] Department of Poultry Science, Fayetteville.

10-lb batches and placed in a 4°C cooler overnight to allow further microbial attachment.

Ten-pound meat batches were next placed individually into a tumbler, and combined with 400 ml of deionized water (control), 5% lactic acid (vol:vol), 10% trisodium phosphate (vol:vol), 0.5% cetylpyridinium chloride (vol:vol), or hot water (82.2°C). A vacuum (20 in Hg) was pulled on each batch and allowed to tumble at 16 rpm for 3 minutes. For non-vacuum treatments, each antimicrobial batch was placed into the tumbler container and tumbled without a vacuum as described above. After tumbling, meat was removed from the tumbler container then ground twice through a 1/8" grinder plate. Samples were then packaged (l lb per package) in oxygen permeable tray overwrap packages and stored under warm white fluorescent lights in a cooler at 4°C to simulate retail storage. On days 0, 1, 2, 3, and 7 of simulated retail storage, 25 g ground beef samples were placed into whirlpack bags with 225 g of .1% buffered peptone water and buffered to a pH of 7 with sodium hydroxide. Serial dilutions and subsequent platings were made on *Salmonella Shigella* agar containing nalidixic acid, Petrifilm (3M Co.) aerobic plate count plates and Petrifilm (3M Co.) *E. coli*/ Coliform plate count plates. Plates were incubated at 37°C. Aerobic plate count plates and *Salmonella Shigella* agar plates were read at 48 hours, while *E. coli* plates were read at 24 hours. Counts were recorded as colony forming units per gram (CFU/g), then transformed to log counts prior to data analysis. This experiment was replicated three times. The randomized complete block 2 (vacuum vs. no vacuum) x 5 (control, cetylpyridinium chloride, hot water, lactic acid or trisodium phosphate) factorial experimental design was analyzed using the GLM procedure of SAS (1988). Least square means were generated and separated using the PDIFF option of PROC GLM.

Results and Discussion

Since no treatment interactions were found ($P > .05$), treatment least-square means were generated and separated as previously described. Figures 1 and 2 show the effects of aerobically applied or anaerobically applied antimicrobial agents on *E. coli* populations through simulated retail storage. For both aerobic and anaerobic treatments, cetylpyridinium chloride, lactic acid and trisodium phosphate were each effective at reducing ($P < .05$) *E. coli* populations through 7 d of simulated retail storage. The control and hot water treatments were not as effective at inhibiting *E. coli* and allowed for *E. coli* growth through the first day of storage. However, although cetylpyridinium chloride, lactic acid and trisodium phosphate were each effective at reducing ($P < .05$) *E. coli* populations through seven days of storage, the magnitude of difference between treatments were small. This is in agreement with Brackett et al. (1994), and Conner et al.(1996) who found little differences with chemical treatments in ground beef systems.

For both aerobically applied or anaerobically applied treatments, cetylpyridinium chloride and trisodium phosphate each had lower ($P < .05$) *Salmonella* counts than either the control, hot water or lactic acid treatments through 7 days of storage (Figs. 3 and 4). Also, for each antimicrobial treatment as well as the control, *Salmonella* counts declined by 1 log through storage. This downward trend in *Salmonella* numbers through storage for all treatments may be due to competitive inhibition of *Salmonella* by other microorganisms.

As with *E. coli*, cetylpyridinium chloride, lactic acid and trisodium phosphate were each effective at reducing ($P < .05$) aerobic bacteria through refrigerated storage compared with the control or hot water treatments (Figs. 5 and 6). As one might expect, the aerobically applied treatments tended to have slightly greater aerobic plate counts than the anaerobically applied treatment.

Cetylpyridinium chloride, lactic acid and trisodium phosphate were also more effective ($P < .05$) at inhibiting coliform bacteria than either the control or hot water treatments (Figs. 7 and 8). Since coliform contamination primarily comes from fecal contamination during carcass dressing, this data would suggest that antimicrobial interventions might be more effective than hot water application for reducing coliform numbers. Likewise, coliform counts tended to be inhibited more by vacuum application in the control and hot water treatments through refrigerated storage, although not statistically significant ($P > .05$). Therefore, use of cetylpyridinium chloride or trisodium phosphate prior to grinding may provide an inhibition for the outgrowth of *E. coli* and *Salmonella* in ground beef during refrigerated storage.

The effect of vacuum treatment with antimicrobial agents on microbial log count of ground beef through simulated retail storage is presented in Table 1. Vacuum application had no effect on *E. coli, Salmonella,* aerobic plate count or coliform counts through seven days of simulated retail storage.

Implications

Data from this study suggest that the use of cetylpyridinium chloride or trisodium phosphate prior to grinding may provide an inhibition for the outgrowth of *E. coli* and *Salmonella* in ground beef during refrigerated storage. Therefore, use of these antimicrobials, perhaps in addition to carcass decontamination technologies, may provide an additional measure of meat safety.

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Table 1. Effect of vacuum treatment with antimicrobial agents on microbial log count of ground beef through simulated retail storage[a].

	Antimicrobial application	
	Aerobic	Vacuum
E. coli, log CFU/g	*6.3*	*6.3*
Salmonella, log CFU/g	5.5	5.5
Aerobic plate count, log CFU/ g	6.8	6.8
Coliform count, log CFU/g	6.0	5.9

[a]Means within the same row do not differ (P > .05)

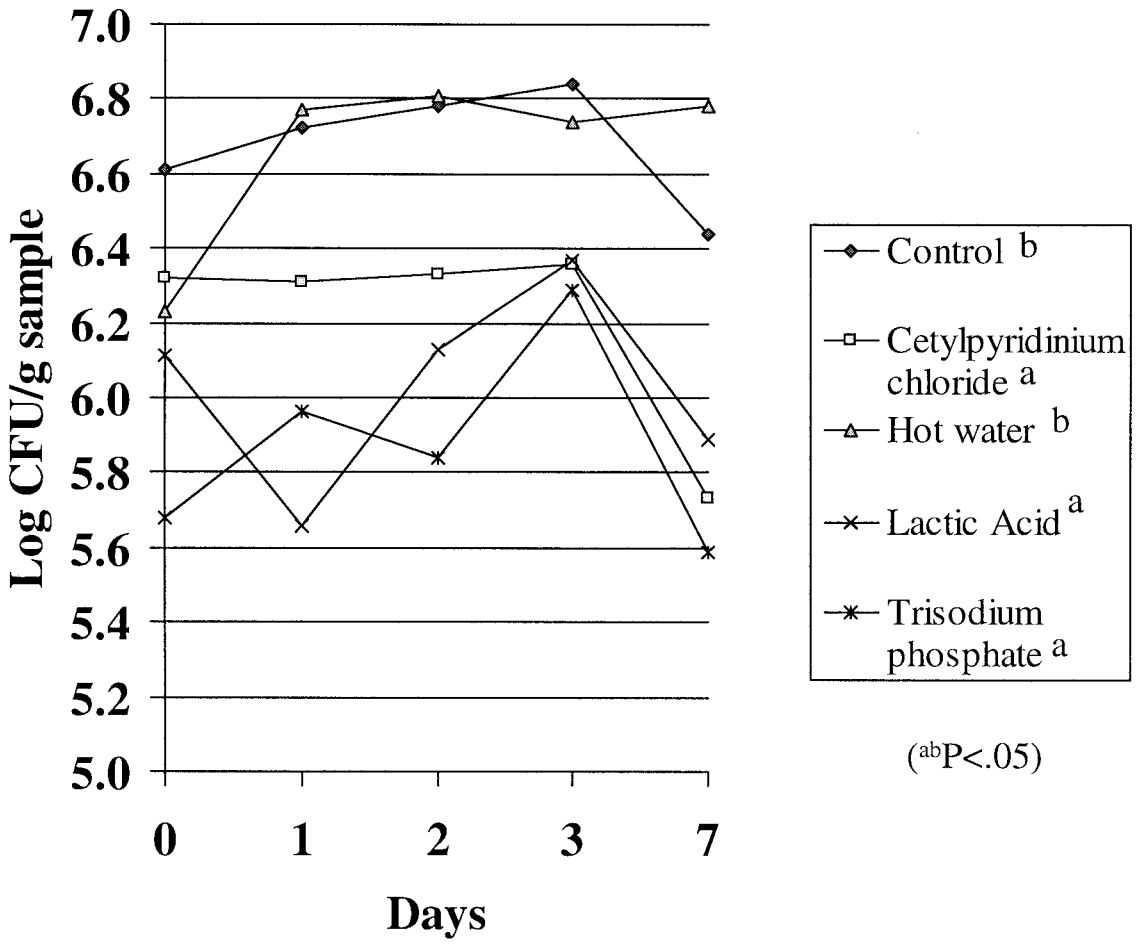

Fig. 1. Effect of aerobically applied antimicrobial agents on *E. Coli* populations through simulated retail storage.

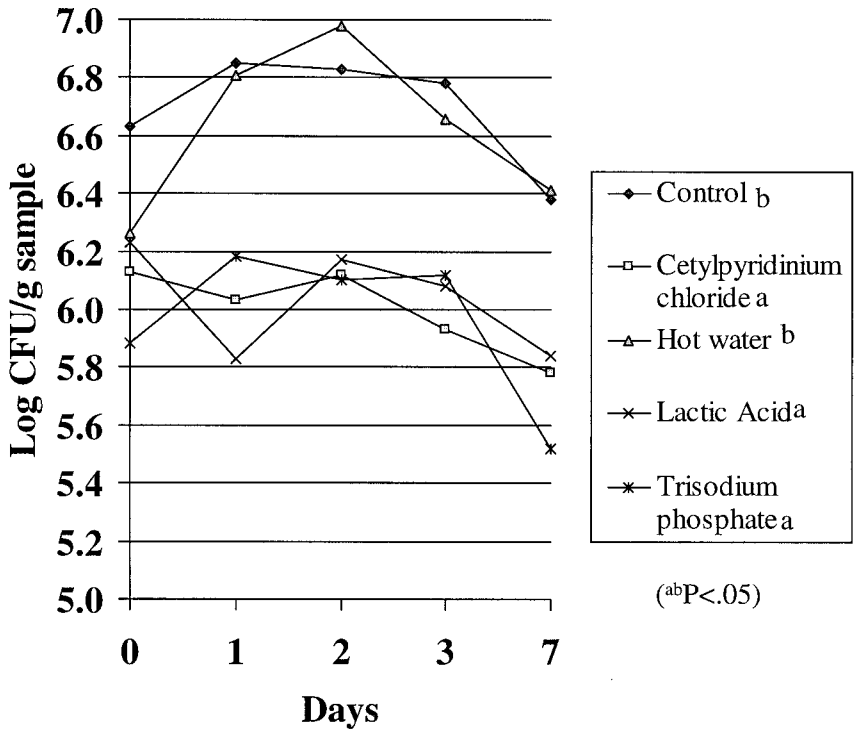

Fig. 2. Effect of vacuum applied antimicrobial agents on *E. Coli* populations through simulated retail storage.

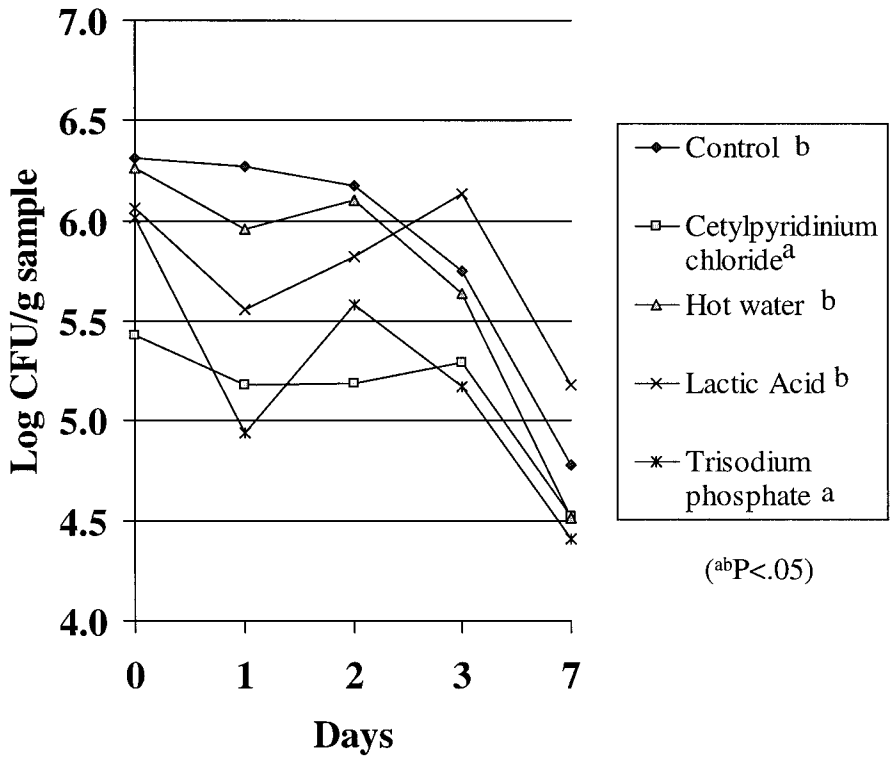

Fig. 3. Effect of aerobically applied antimicrobial agents on *Salmonella* populations through simulated retail storage.

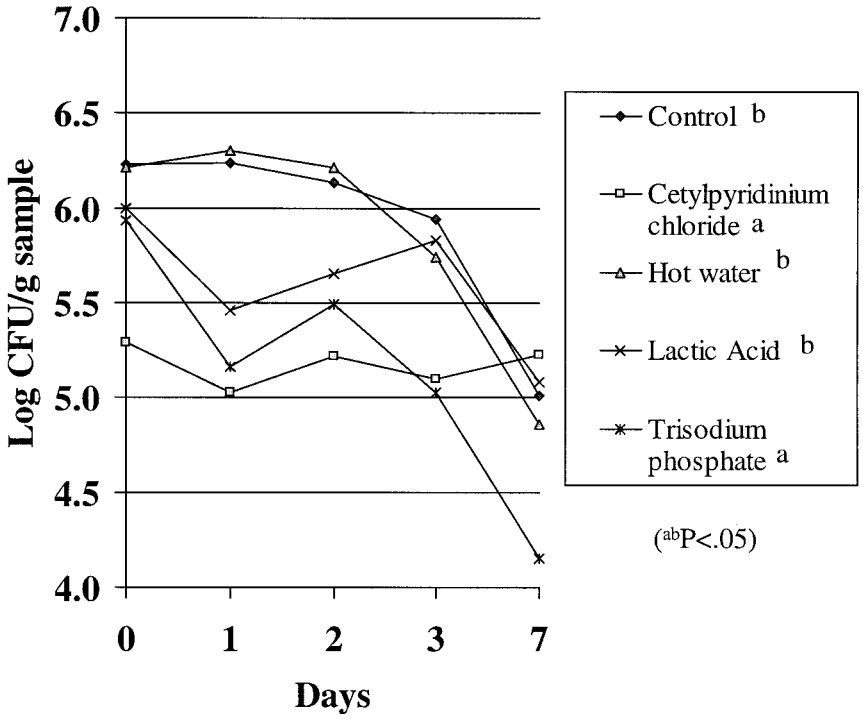

Fig. 4. Effect of vacuum applied antimicrobial agents on *Salmonella* populations through simulated retail storage.

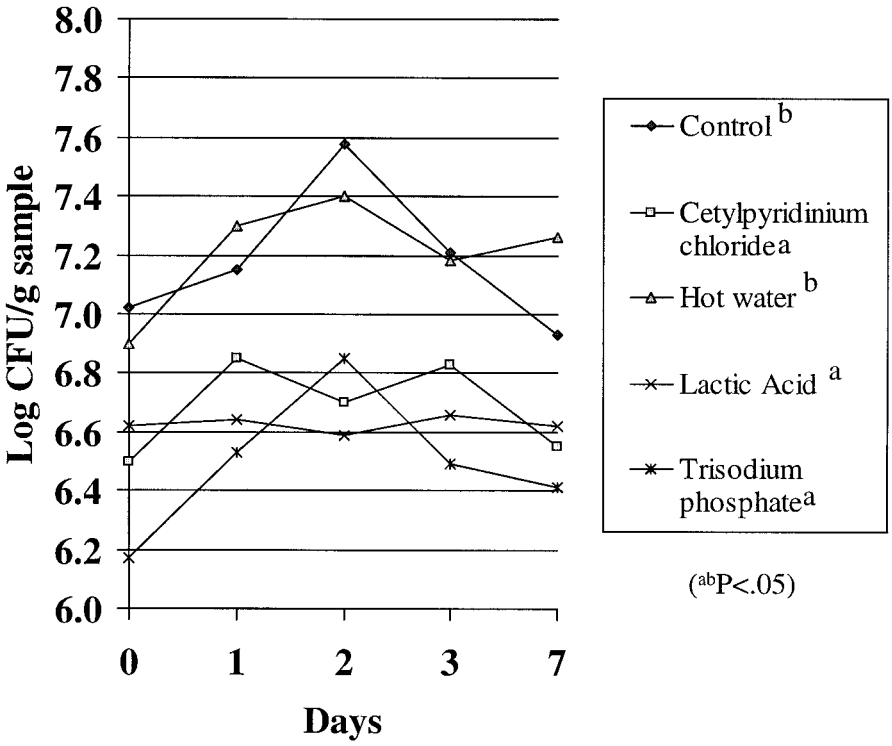

Fig. 5. Effect of aerobically applied antimicrobial agents on aerobic plate count through simulated retail storage.

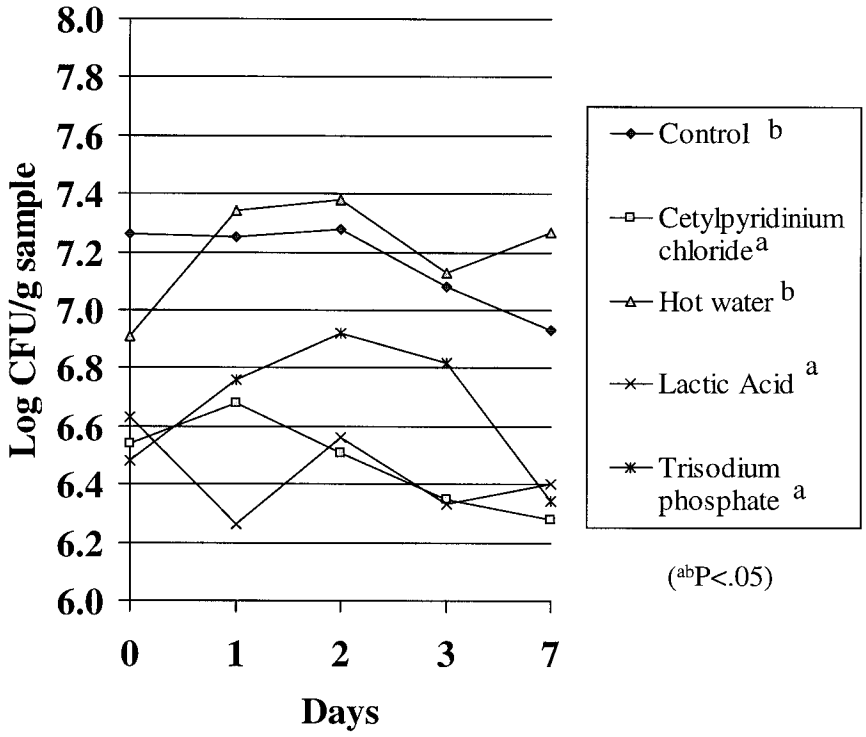

Fig. 6. Effect of vacuum applied antimicrobial agents on aerobic plate count through simulated retail storage.

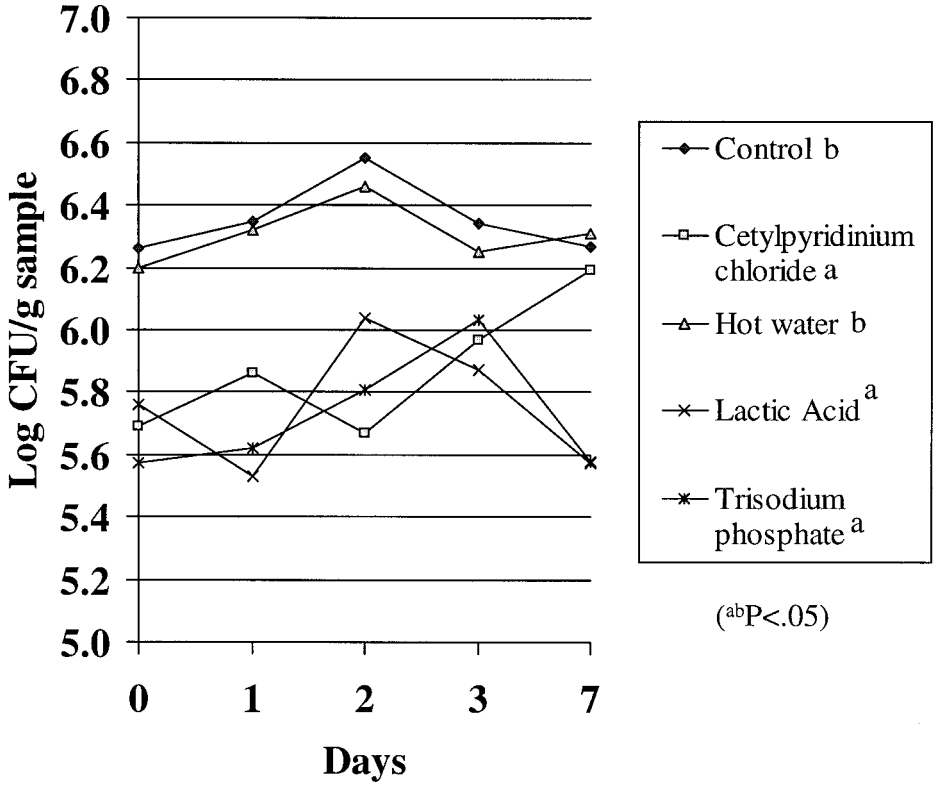

Fig. 7. Effect of aerobically applied antimicrobial agents on coliform count through simulated retail storage.

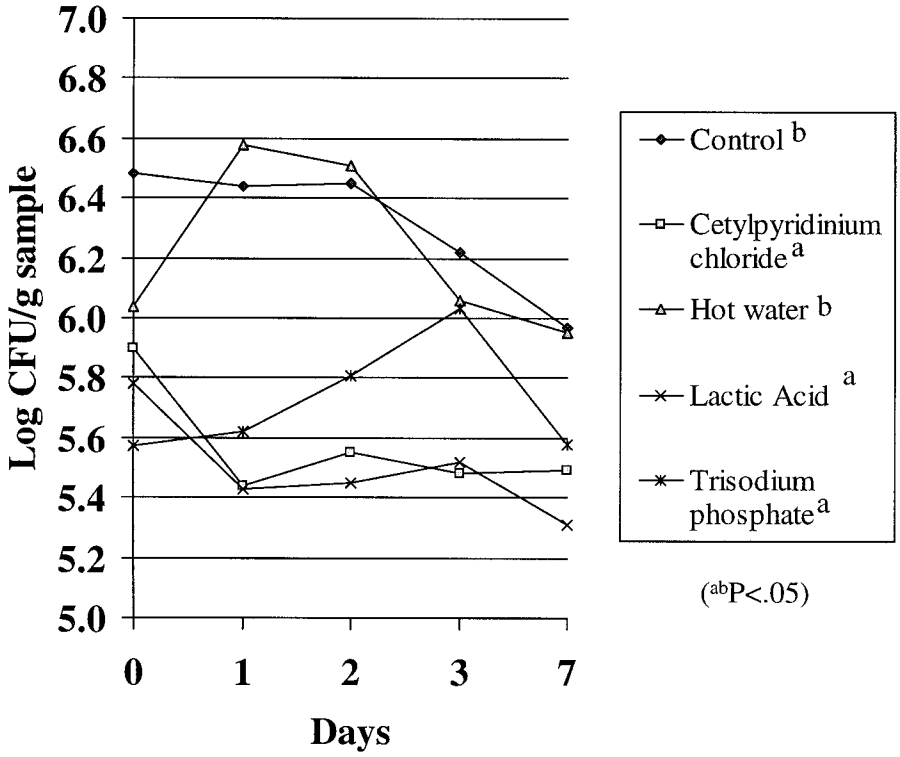

Fig. 8. Effect of vacuum applied antimicrobial agents on coliform count through simulated retail storage.

Performance and Ensiling Characteristics of Tall Growing Soybean Lines Used for Silage

Venerand Nayigihugu[1], Wayne Kellogg[1], David Longer[2], Zelpha Johnson[1], and Karen Anschutz[1]

Story in Brief

Seven tall growing soybean (*Glycine max* [L.] Merr.) lines, including the cultivars 'Derry', 'Donegal', and 'Tyrone' plus the experimental lines 'OR 5-12-1T', 'OR 13-12-3', 'OR 19-12-2' and 'PA 5-2-1', were ensiled and tested for nutritive quality to evaluate the potential of these lines as silage crops. The trial included a grain type soybean ('Hutcheson') and sorghum (*Sorghum bicolor* [L.] Moench) ('Pioneer 838 F') varieties as checks. Lines were replicated four times at sites near Fayetteville and Rohwer, Arkansas in 1995 and 1996. Forages were harvested at full seed (soybean growth stage R-6) and ensiled for 33 days. There was no clear advantage to selecting a specific line of tall soybean because interactions between lines and years occurred, so data is presented separately. The three cultivars Derry, Donegal, and Tyrone produced average DM yields of 4,678, 6,356, and 6,162 lb/acre at Fayetteville and 6,018, 5,713, and 6,018 lb/acre at Rohwer, respectively. The tallest entries grown in Fayetteville were Tyrone and 'OR 13-12-3', while Derry was tallest at Rohwer in 1995. Mean concentrations of ADF in silage from Derry, Donegal, and Tyrone were 33.0, 33.6, and 33.2% at Fayetteville and were 33.9, 37.0, and 31.3% at Rohwer. Mean concentrations of CP in silage from Derry, Donegal, and Tyrone were 12.6, 14.2, and 14.0% at Fayetteville and were 13.8, 16.0, and 13.7% at Rohwer. Average IVDMD of silage from Derry, Donegal, and Tyrone were 70.4, 72.1, and 70.6% at Fayetteville and were 63.0, 66.8, and 62.5% at Rohwer. Silage for all lines was well preserved as indicated by the low final pH and a high lactic acid concentration. Silage type soybeans should compete for light better than the grain type soybeans when grown with crops like corn or sorghum. This should improve concentration of CP of the companion crop and the silage mixture and produce high DM yields.

Introduction

New lines of soybean (*Glycine max* [L.] Merr.) have been selected specifically for use as forage rather than grain crops. Three cultivars, 'Derry', 'Donegal' and 'Tyrone', have been released for forage production. In contrast to corn (Zea mays) and sorghum (*Sorghum bicolor* [L.] Moench), soybean is a legume crop that fixes atmospheric nitrogen. Legumes reduce the need for extensive field application of nitrogen and produce forage with higher protein concentration than corn or sorghum.

Most of the research on soybeans as a forage crop has focused on its value as hay (Hubbell et al., 1988). However, soybeans have been inter-cropped with sorghum (Coats, 1966) or with corn (Christosov, 1972; Wiggans, 1935) to improve the protein concentration of silage. Total digestible nutrients (TDN) increased in silage when corn and soybean were inter-cropped compared to growing either crop alone (Wiggans, 1935). There has been limited research on soybean for silage, however grain type soybean cultivars were grown in monoculture and evaluated for nutrient content (Coffey et al., 1995a) and for *in vitro* digestibility and forage preference by sheep (Coffey et al., 1995b).

The soybeans used for silage in this study were developed by Thomas Devine (USDA/ARS) in Beltsville, Maryland. These recently developed tall soybean lines have attained heights up to 82 in and should compete favorably for light when inter-planted with corn or sorghum. A mixed crop containing a legume should require less nitrogen fertilization, and protein levels of the harvested silage should be improved relative to corn or sorghum. Therefore, the objectives of this study were to evaluate the performance and the ensiling characteristics of seven tall growing soybean lines and compare these values to a grain type soybean and to a forage type sorghum.

Materials and Methods

Seven tall growing soybean lines were grown at two locations in Arkansas (the Arkansas Agricultural Experiment

[1] Department of Animal Science, Fayetteville.
[2] Crop, Soil, and Environmental Sciences Department, Fayetteville.

Station in Fayetteville and the Southeast Research and Extension Center, Rohwer Division) in 1995, and five lines were grown in 1996. The seven lines consisted of three cultivars (Derry, Donegal and Tyrone) and four experimental lines ('PA 5-2-1', 'OR 5-12-1T', 'OR 13-12-3', and 'OR 19-12-2') and were ensiled and tested for nutritive quality and compared to a typical grain type soybean ('Hutcheson') and a forage sorghum ('Pioneer 838 F') in 1995. Seed was not available to plant 'OR 13-12-3' and 'OR 19-12-2' the second year. Each line was replicated four times at each site. Other agronomic techniques and plot management can be found in Table 1.

Whole-plant soybeans were harvested at full seed (R-6; Fehr and Caviness, 1977), chopped, and packed in 3-mil standard barrier bag silos. Approximately 1.03 X 10-5 Pa of vacuum was applied to each bag using vacuum pump designed for a portable milking machine. Forages were allowed to ferment at room temperature. Silos were sampled on day 33, silage pH was determined, and approximately 450 g of sample were frozen in 2-mil sealable plastic bags maintained at -10°C. An aqueous extract was obtained by blending 50 g of frozen sample with 225 ml of distilled water for 2 minutes in a blender and straining the mixture through four layers of cheesecloth (Parker, 1981). Acetic and lactic acid concentrations were determined by gas chromatography (Parker, 1981; Supelco, 1975; 1990) on 1995 silage samples. Later, remaining frozen silage samples were weighed, freeze-dried, and weighed again for moisture determination. Dry samples were ground for chemical analyses, and CP (AOAC, 1984), ADF, and NDF (Goering and Van Soest, 1970) were determined. The IVDMD was determined by procedures outlined by Marten and Barnes (1979).

Data were subjected to analysis of variance (ANOVA) using the GLM procedure of SAS (1985). All reported effects were significant at ($P < .05$).

Results and Discussion

Because significant interactions occurred between lines and years, means for each year are presented separately in Tables 2 to 5. Interactions may be due to varying response to climatic conditions. Tall soybean types tested in this study performed well, as indicated by their DM yields. Among these soybeans, DM yield was highest for Tyrone and 'OR 5-12-1T' and was lowest for Derry when grown at Fayetteville in 1995 (Table 2). In 1996, Donegal produced the highest DM yields at Fayetteville (Table 3). However, in 1995, Derry was the highest yielding silage type at Rohwer, and 'OR 13-12-3' was the lowest (Table 4). In 1996 'OR 5-12-1T' and 'PA 5-2-1' produced more DM than Donegal or Tyrone when grown in Rohwer (Table 5). This is a typical genotype x environment interaction. In 1995, the grain type soybean, Hutcheson, produced the highest DM yield of all soybean lines at Rohwer (Table 4) but was the lowest in DM yield at Fayetteville (Table 2). Hutcheson was the shortest at both locations in 1995 (the only year that heights were measured), averaging 30 and 28 in tall at Fayetteville (Table 2) and Rohwer (Table 4), respectively. Tyrone and 'OR 13-12-3' were the tallest (56 and 53 in, respectively) when grown at Fayetteville in 1995, while Derry produced the tallest plants (78 in) at Rohwer.

The ADF percentages for Donegal were higher than for 'OR 13-12-3' and 'OR 19-12-3' among silage type soybeans grown at Fayetteville in 1995 (Table 2). However, in 1996 ADF concentrations of Donegal and 'PA 5-2-1' were lower than Derry and 'OR 5-12-1T' (Table 3). Of the silage type soybeans grown at Rohwer, Donegal and 'PA 5-2-1' contained the lowest concentrations of ADF in 1995 (Table 4), and 'Donegal was lowest in ADF concentration in 1996 (Table 5).

In 1995, percentages of NDF were similar for all silage types grown at Fayetteville (Table 2). In 1996 Donegal and 'PA 5-2-1' contained the lowest concentration of NDF while Derry and 'OR 5-12-1T' had the highest percentages of NDF of silage type soybeans grown at Fayetteville (Table 3). Both Donegal and 'PA-5-2-1' contained lower NDF percentages than Derry and Tyrone when grown at Rohwer during either year (Table 4 and 5).

There were no differences among CP concentrations of Donegal, Tyrone, 'OR 19-12-3', and 'PA 5-2-1' at Fayetteville in 1995, and CP concentrations of Derry, 'OR 5-12-1T', and "OR 13-12-3' were lowest among silage type lines (Table 2). Values ranged from 14.0 to 15.9% CP for the silage types compared to 17.5 for Hutcheson. In 1996 percentages of CP ranged from 11.9 for Derry to 13.7 for Donegal when grown at Fayetteville compared to 13.2 for Hutcheson (Table 3). In 1995 Donegal and 'PA 5-2-1' had higher CP concentrations when grown at Rohwer than other silage type lines (Table 4). The range in CP values of silage type soybeans was from 11.6 for Tyrone to 16.2 for 'PA 5-2-1', while Hutcheson contained 15.8% CP. In 1996 CP concentration of 'OR 5-12-1T' was lower than other silage type soybeans (Table 5). The range in CP values of silage type soybeans was from 13.8 for 'OR 5-12-1T' to 16.0 for Donegal, while Hutcheson contained 16.6% CP.

In 1995, percentages of IVDMD were similar for all silage type lines grown at Fayetteville (Table 2). In 1996 at Fayetteville, Donegal had the highest percentage of IVDMD while Tyrone was lowest in IVDMD among silage type soybeans (Table 3). Of the silage type soybean lines grown at Rohwer in 1995, Derry, Tyrone, and 'OR 5-12-1T' had lower percentages of IVDMD than 'OR 19-12-2' (Table 4). In 1996 at Rohwer, Derry, Donegal, and Tyrone had higher IVDMD percentages than 'PA 5-2-1' and 'OR 5-12-1' (Table 5).

None of the three released cultivars had a clear advantage at both locations. Either Donegal or Tyrone performed better and had at least equal nutritive value compared to Derry when grown at Fayetteville, while Donegal had lower fiber concentration and higher protein concentration which provided a higher IVDMD percentage at Rohwer compared to the higher producing cultivar, Derry, or to the cultivar Tyrone.

All lines produced silage that was adequately preserved, as indicated by pH. After 33 d of ensiling, means of pH and lactic acid in soybean silage ranged from 4.3 to 4.7 and from

.9 to 1.3%, respectively (Table 6). Apparently, there was enough fermentable carbohydrate for proper fermentation by lactic acid bacteria (*Lactobacillus* ssp.), so these measures of acid production were not repeated the second year.

This study confirms that the grain type soybean produced higher CP than tall soybean lines. The seeds are very high in protein, so this is not surprising. Hutcheson was shorter and had bigger pods and more grain than tall soybeans. While Hutcheson is bred to produce grain, the silage types are bred to produce stems and leaves. As the soybean plant matures NDF and ADF concentration increases, while CP concentration decreases for leaf and stem components. The greatest changes occur as soybean plants mature from stage R5 to stage R7 (Munoz et al., 1983). The pod component shows an opposite trend, with NDF and ADF concentrations decreasing and an increase of CP concentration.

Implications

Lower ADF and higher CP concentrations are associated with improved nutritive quality and are usually inversely related in forage crops. Most of the tall soybean lines tested exhibited good performance in this area. This is based on plant heights and acceptable nutritive quality. Silages were preserved adequately, as indicated by the silage pH, and volatile fatty acid and lactic acid concentrations were indicative of silage that had fermented well. Of the tall soybeans tested, 'PA-5-2-1'and Donegal had consistently higher nutritive values at both locations for two consecutive years than other silage type soybeans. However, each of the soybean types tested in this experiment would dramatically improve the protein content of corn or sorghum when grown together. Plant height and yield of tall growing soybeans are important traits to consider when inter-cropping with either corn or sorghum with soybeans. Tall growing soybeans reported in this study produced DM yields up to 8234 lb/acre at heights up to 78 in. These two traits, together with CP and digestibility are important factors that need to be considered when inter-cropping soybean and corn or sorghum for silage.

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Table 1. Plot management and agronomic practices used for Rohwer and Fayetteville in 1995 and 1996.

Location	Rohwer		Fayetteville	
	1995	1996	1995	1996
Soil name and type	Desha silt loam	Desha silt loam	Johnsburg Silt Loam	Captina Silt Loam
Replications	4	4	4	4
Section of row harvested	39 in	39 in	39 in	39 in
Herbicide and rate	Treflan, 4.57 qt/A Scepter, 1.02 qt/A Reflex, 4.57 qt/A	Dual, 6.11 qt/A Roundup, 15.2 lb/A Scepter, .914 lb/A	Roundup, 6.11 qt/A Treflan, 3.81 qt/A Scepter, .914 lb/A	Roundup, 6.11 qt/A Treflan,3.81qt/A Basagran, 4.57 qt/A
Seeding rate	Soybean- 3 seeds/ft row Sorghum- -6 seeds/ft row	Soybean- 3 seeds/ft row Sorghum- -6 seeds/ft row	Soybean- 3 seeds/ft row Sorghum- -6 seeds/ft row	Soybean- 3 seeds/ft row Sorghum- -6 seeds/ft row
Fertilizer used and rate	None	None	0 – 40 – 0	0 – 40 – 60
Plot size	4 rows, 78 in long	4 rows, 78 in long	4 rows, 78 in long	4 rows, 78 in long
Planting dates	May 12	May 13	May 14	May 24
Harvesting dates (R-6)	August 24 or September 13	September 6	September 22	September 14
Row spacing	38 in	38 in	38 in	38 in

Table 2. Nutrient composition, heights, and DM yields of silage from soybean lines grown at Fayetteville in 1995.

Soybean lines	DM (%)	ADF (%)	NDF (%)	CP (%)	IVDMD (%)	Height (in)	DM yields (lb/acre)
PA 5-2-1	35.2^{a}	32.7^{bcd}	39.7^{b}	14.8^{bcd}	70.2^{abc}	39^{b}	4482^{c}
Donegal	34.9^{a}	34.4^{abc}	42.1^{b}	14.7^{bcd}	72.9^{ab}	37^{c}	4478^{c}
OR 5-12-1T	34.6^{a}	30.8^{cd}	41.5^{b}	14.3^{cd}	65.4^{bc}	49^{ab}	5231^{b}
Tyrone	31.6^{b}	33.1^{bcd}	40.2^{b}	15.7^{bc}	73.2^{ab}	56^{a}	5490^{b}
Derry	31.8^{b}	32.1^{bcd}	40.1^{b}	14.0^{d}	71.7^{ab}	44^{b}	3138^{d}
OR 13-12-3	32.8^{b}	29.9^{d}	39.8^{b}	14.4^{cd}	72.5^{ab}	53^{a}	4637^{c}
OR 19-12-2	30.4^{bc}	29.7^{d}	38.4^{b}	15.9^{b}	68.9^{bc}	46^{b}	4612^{c}
Hutcheson	30.3^{c}	35.8^{ab}	34.2^{c}	17.5^{a}	75.7^{a}	30^{c}	2744^{c}
Pioneer 838 F	21.3^{d}	38.6^{a}	64.1^{a}	7.0^{c}	54.2^{d}	-	6678^{a}

^{abcde} Means within the same column with different superscripts are different ($P < .05$).

Table 3. Nutrient composition and DM yields of silage from soybean lines grown at Fayetteville in 1996.

Soybean lines	DM (%)	ADF (%)	NDF (%)	CP (%)	IVDMD (%)	DM yields (lb/acre)
PA 5-2-1	34.4[a]	30.5[c]	41.7[c]	13.4[a]	69.4[b]	6800[c]
Donegal	32.2[b]	30.8[c]	45.6[a]	13.7[a]	71.4[a]	8234[a]
OR 5-12-1T	31.2[bc]	33.4[a]	43.9[b]	12.6[b]	68.8[b]	6682[c]
Tyrone	32.4[ab]	33.2[b]	46.0[a]	12.3[b]	68.1[c]	6802[c]
Derry	29.3[c]	33.9[a]	43.5[b]	11.9[c]	69.2[ab]	6177[d]
Hutcheson	31.5[bc]	28.8[c]	37.7[d]	13.2[a]	72.6[a]	6399[cd]
Pioneer 838 F	28.8[c]	24.3[d]	48.0[a]	6.2[d]	70.7[ab]	7499[b]

[abcde] Means within the same column with different superscripts are different (P < .05).

Table 5. Nutrient composition, heights, and DM yields of silage from soybean lines grown at Rohwer in 1995.

Soybean lines	DM (%)	ADF (%)	NDF (%)	CP (%)	IVDMD (%)	Height (in)	DM yields (lb/acre)
PA 5-2-1	28.5[bc]	34.3[d]	43.5[d]	16.2[a]	62.3[abc]	54[c]	6689[cd]
Donegal	29.7[abc]	34.1[d]	46.5[cd]	16.0[a]	57.4[bcd]	61[d]	6497[d]
OR 5-12-1T	30.1[abc]	38.8[b]	48.1[bc]	13.2[ab]	54.5[d]	74[b]	6054[e]
Tyrone	30.3[abc]	40.1[a]	50.1[ab]	11.6[d]	54.7[cd]	69[c]	6518[d]
Derry	32.8[a]	38.1[b]	50.2[ab]	12.1[cd]	55.5[cd]	78[a]	6977[c]
OR 13-12-3	32.3[ab]	40.1[a]	48.1[bc]	11.9[d]	59.0[bcd]	70[c]	5684[f]
OR 19-12-2	27.4[c]	37.7[c]	48.9[bc]	13.8[b]	64.0[ab]	26[ab]	6364[d]
Hutcheson	28.0[c]	32.5[b]	45.1[cd]	15.8[a]	68.0[a]	28[f]	8313[b]
Pioneer 838 F	30.3[abc]	31.7[c]	53.7[a]	6.1[c]	58.5[bcd]	-	19307[a]

[abcdef] Means within the same column with different superscripts are different (P < .05).

Table 5. Nutrient composition and DM yields of silage from soybean lines grown at Rohwer in 1996.

Soybean lines	DM (%)	ADF (%)	NDF (%)	CP (%)	IVDMD (%)	DM yields (lb/acre)
PA 5-2-1	30.8[a]	31.1[c]	40.2[d]	15.9[a]	54.6[b]	5382[a]
Donegal	32.6[a]	28.5[d]	42.6[c]	16.0[a]	74.1[a]	4929[b]
OR 5-12-1T	33.4[a]	35.0[a]	45.7[a]	13.8[b]	67.3[b]	5599[a]
Tyrone	30.9[b]	34.0[b]	46.1[a]	15.8[a]	70.6[a]	4753[b]
Derry	33.2[a]	29.6[c]	44.6[b]	15.6[a]	70.6[a]	5059[ab]
Hutcheson	32.0[a]	29.8[c]	38.5[d]	16.6[a]	74.4[a]	5532[a]
Pioneer 838 F	32.3[a]	31.1[c]	41.5[c]	6.0[c]	70.7[a]	5195[a]

[abcde] Means within the same column with different superscripts are different (P < .05).

Table 6. Means of pH, acetic acid, and lactic acid after 33 days of ensiling soybean lines grown at Rohwer in 1995.

Soybean lines	pH	Acetic acid (% of DM)	Lactic acid (% of DM)
PA 5-2-1	4.6[ab]	5.3[d]	1.0[b]
Donegal	4.7[a]	6.2[a]	1.3[b]
OR 5-12-1T	4.5[ab]	4.9[ab]	1.3[b]
Tyrone	4.3[c]	4.2[b]	1.1[b]
Derry	4.5[ab]	3.4[b]	1.2[b]
OR 13-12-3	4.3[c]	3.9[b]	0.9[c]
OR 19-12-2	4.4[c]	5.2[a]	1.3[b]
Hutcheson	4.5[ab]	5.6[a]	1.8[a]
Pioneer 838 F	3.7[d]	-	-

[abcde] Means within the same column with different superscripts are different (P < .05).

Nutrient Composition of Hays Produced in Arkansas

George Davis, Tom Troxel, and Shane Gadberry[1]

Story in Brief

The University of Arkansas Cooperative Extension Service hay database consists of nutrient analyses of 7,647 hay samples collected from farms in 74 of 75 counties in the state. Twenty-three species of hay were represented in the database. Bermudagrass (2,568), mixed grass (2,010) and fescue (911) were the species with the highest numbers of samples. The objective of compiling the database was to determine the average composition of hays produced in Arkansas.

Database values show that hay is highly variable in nutrient content. For beef cows and calves, total digestible nutrient (TDN) levels were deficient in a higher percentage of hays than crude protein (CP) levels. Bermudagrass hays contained greater ($P < .05$) levels of CP, TDN and sulfur (S) but lower ($P < .05$) levels of magnesium (Mg) than fescue or mixed grass hays. Fescue contained greater ($P < .05$) levels of CP and TDN than mixed grass. Mixed grass hays, however, contained greater ($P < .05$) levels of calcium (Ca) and phosphorus (P) than bermudagrass. For beef cows and calves, a high percentage of the hays were deficient in sodium (Na), selenium (Se), copper (Cu), and zinc (Zn). A lower percentage of the hays were deficient in P, Ca, Mg and S. Iron (Fe), manganese (Mn) and potassium (K) were deficient in a very small percentage of the hays analyzed.

Introduction

Arkansas beef cattle producers provide hay to cattle herds for two to five months during the winter and early spring. Because most beef cow herds calve in the late winter and early spring, feed supplementation is often necessary to maintain or bring cows to a moderate body condition (body condition score of 5 on a scale of 1 to 9) by the start of the breeding season. Also, hay is often provided to stockers or replacement animals when pasture forage is unavailable.

The quality of hay produced throughout the state is highly variable in nutrient content. Therefore, to improve the use of hay and prevent costly over- and under-feeding mistakes, hay should be analyzed for nutrient composition. When forage composition values aren't available, the use of tabular values is usually better than visual appraisal alone. The objective of compiling this hay database was to provide county extension agents, cattle producers, and cattle-related industries with a source of nutrient analysis data that could be used in estimating nutrient content of hay whenever a forage test is unavailable.

Experimental Procedures

The hay composition database was compiled by the University of Arkansas Cooperative Extension Service from forage analysis reports provided by the University of Arkansas Diagnostic Laboratory in Fayetteville. Hay composition values in this report were compiled from 7,647 hay samples collected throughout the state from 1985 to 1996.

Hay samples were submitted for analysis from 74 of 75 counties in the state. The 10 counties that submitted the most samples for analysis and the number of samples submitted per county were as follows: Washington, 1044; Benton, 623; Independence, 489; Logan, 431; Crawford, 323; Sebastian, 270; Hempstead, 263; Carroll, 255; Van Buren, 230; and Madison, 225.

The number of hay samples analyzed by the Diagnostic Laboratory increased from 1985 to 1996 due to promotion of hay testing by county extension agents. The respective number of hay samples analyzed per year from 1985 to 1996 were 134, 186, 284, 606, 597, 526, 672, 867, 774, 986, 868, and 1,147.

A complete nutrient analysis was not conducted on every hay sample submitted. Samples were analyzed for one (usually nitrate N) to fifteen nutrients. These included moisture, N, acid detergent fiber (ADF), neutral detergent fiber (NDF), nitrate-N, phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sodium (Na), sulfur (S), iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu). Selenium analysis was conducted on a limited number of hay samples at Michigan State University. Crude protein content was calculated as nitrogen times 6.25 and TDN was estimated with prediction equations using CP, ADF and for some species NDF.

Individual quality characteristics were analyzed for species main effect. The species included bermudagrass, fescue, and mixed grass. The number of samples submitted between 1985 and 1996 were 2568, 911, and 2010, respectively. Since samples submitted to the lab represented different farms from year to year, the main effect of year and the year x species

[1]All authors are associated with the Animal Science Section, Cooperative Extension Service, Little Rock

interaction effect on quality characteristics were not included in the analysis. Due to unequal sample sizes and missing observations, statistical differences were determined using the PROC GLM procedure of SAS (1990). Least-square means were computed (SAS, 1990) and were presented throughout.

Results and Discussion

The composition of hays from Arkansas farms is shown in Table 1. Twenty-three species of hays were analyzed. Bermudagrass, fescue, and mixed grass hays were the primary species produced on beef farms. The average nutrient values of all 23 species are also shown in Table 1.

Crude protein and TDN usually make up over 95% of the nutrients required by cattle. Bermudagrass hays contained greater ($P < .05$) levels of CP and TDN than fescue or mixed grass hays. Fescue hays contained greater ($P < .05$) amounts of CP and TDN than mixed grass hays.

Hays were produced under various management conditions, with differences in plant maturity, soil fertility, rainfall, and other environmental influences. Typically, bermudagrass is managed for hay production more than either fescue or mixed grass. Some hybrid bermudagrasses are known for their high yield of high-quality forage. Summer weather is usually a more favorable time to harvest hay. Fescue, however, is a cool season grass that reaches a good compromise between yield and quality during the spring when rainfall often interferes with harvest. Therefore, harvest is sometimes delayed; this allows fescue to mature past the desired growth stage for harvest. Stage of maturity at harvest, as well as other factors, are likely to be involved in the nutrient differences shown here.

The range (lowest to highest value) in CP and TDN concentrations of the hays shows variability in the quality of the hays. The greatest range in quality was observed for mixed grass hays. The highest CP value for mixed grass (24.3 percent) was over 11 times greater than the lowest value (2.1 percent). The highest CP values for bermudagrass and fescue were six and five times the lowest values, respectively. Considerable variability in TDN content also occurred among the hays. The high variability in CP and TDN emphasizes the importance of obtaining a CP and TDN analysis on hay before it is fed. A hay analysis can be used to determine the deficiency of nutrients in the animal's diet. An analysis can also be used to balance diets more efficiently and reduce costly over- and under-feeding errors.

Many of these hays contained excessive amounts of nitrate-N. Bermudagrass hays were lower ($P < .05$) in nitrate-N than fescue or mixed grass hays. The variability in nitrate-nitrogen content was high as indicated by the wide ranges in values and high associated standard deviation values. Forage with over 2,100 ppm of nitrate-N is potentially lethal. Pregnant cattle should not be fed a diet containing more than 700 ppm nitrate-N.

Calcium, P, and Mg concentrations in mixed grass hays were greater ($P < .05$) than in bermudagrass hays. Concentrations of these minerals in fescue hays were similar to those in mixed grass hays. Fescue hays had greater ($P < .05$) concentrations of Mg and less S ($P < .05$) than did bermudagrass. No differences among hays were found in the other minerals analyzed.

The nutrient values in Table 1 should not be used to replace a hay analysis. However, in situations where an analysis is unavailable, these values could be used with visual appraisal of hay quality to make a more reasonable estimation of nutrient content.

Nutrient requirements of diets for beef cows and growing calves (Table 2) were compared with the nutrient composition values of all hays in the hay database (Table 1) to determine the percentage of all hays that were deficient in various nutrients for these cattle, as shown in Table 3. Ranked from lowest to highest nutrient requirements were dry gestating cow, lactating cow, and growing calf. Therefore, a higher percentage of the hays were deficient in various nutrients for the growing calf, followed by the lactating cow and then the dry, gestating cow.

Compared to CP, TDN was deficient in a higher percentage of hays for all cattle. To maintain adequate performance of these animals, TDN supplementation would be required with a high percentage of the hays, especially for growing calves and lactating cows.

For dry and lactating cows, P was deficient in a higher percentage of hays than Ca. However, for growing calves, Ca was deficient in a higher percentage of hays than P (Table 3). Only a small percentage of hays were deficient in Fe, Mn, and K.

Sodium was the most deficient mineral in the hays tested. Less than 12 percent of all hays in the database contained adequate Na. Trace minerals Se, Cu, and Zn were deficient in a high percentage of the hay samples. These three trace minerals have been shown to be related to the immune function in cattle.

Data in Table 3 show that mineral supplementation should be recommended with most hay diets to maintain optimum animal performance. The most common mineral deficiencies in hays for beef cows and calves were Na, Se, Cu, and Zn. A smaller percentage of the hays were deficient in P, Ca, Mg and S. Only a small percentage of hay samples were deficient in Fe, Mn, and K.

Implications

Hays produced in Arkansas are highly variable in nutrient content. For beef cows and calves, TDN deficiency is more prevalent in hays than CP deficiency. The most common mineral deficiencies in hays for beef cows and calves were Na, Se, Cu, and Zn. A lower percentage of hays were deficient in P, Ca, Mg and S. Very few hays were deficient in Fe, Mn, and K.

Literature Cited

SAS. 1990. SAS Inst., Inc., Cary, North Carolina.

Table 1. Composition of hays from Arkansas farms, 1985-1996.

Item	Item	Bermudagrass	Fescue	Mixed grass	Pooled SE	All hays[1]
Dry matter, %	avg[2]	87.4 (2238)[3]	87.3 (652)	87.4 (1638)	0.2	87.3 (5905)
	range[4]	61.2-96.8	64.4-94.9	60.0-99.0		60.-99.0
	SD[5]	4.6	4.8	4.8		4.9
Crude protein, %	avg	12.3[a](2269)	11.2[b] (649)	11.0[c] (1665)	0.1	11.9 (5996)
	range	3.7-23.7	4.3-21.5	2.1-24.3		2.1-28.6
	SD	3.6	2.8	3.2		2.8
TDN, %	avg	59.2[a] (2261)	53.6[b] (645)	52.4[c] (1653)	0.2	56.4 (5949)
	range	39.6-79.0	42.2-69.9	37.2-69.9		28.1-79.0
	SD	6.3	4.6	4.7		6.6
Nitrate-nitrogen, ppm	avg	804[a] (1080)	1127[b] (533)	905[b] (921)	41	1062 (3774)
	range	40-8,000	34-15,000	60-8,200		34-15,000
	SD	819	1580	1067		1332
Calcium, %	avg	0.51[a] (185)	0.50[ab] (52)	0.58[b] (251)	0.02	0.59 (585)
	range	0.10-1.21	0.24-0.85	0.12-3.06		0.10-3.06
	SD	0.17	0.16	0.27		0.28
Phosphorus, %	avg	0.27[a] (192)	0.31[ab] (50)	0.30[b] (249)	0.01	0.29 (586)
	range	0.08-0.61	0.11-0.50	0.04-0.66		0.04-0.66
	SD	0.08	0.08	0.11		0.10
Potassium, %	avg	1.85 (179)	2.11 (47)	1.88 (230)	0.07	1.92 (540)
	range	0.68-3.60	0.61-3.71	0.29-5.03		0.29-5.03
	SD	0.59	0.68	0.74		0.67
Magnesium, %	avg	0.22[a] (180)	0.26[b] (49)	0.26[b] (238)	0.01	0.24 (552)
	range	0.08-0.46	0.17-0.51	0.10-0.75		0.04-0.75
	SD	0.07	0.07	0.11		0.09
Sulfur, %	avg	0.26[a] (192)	0.21[b] (40)	0.22[b] (208)	0.01	0.23 (518)
	range	0.02-0.63	0.12-0.36	0.10-0.49		0.02-0.63
	SD	0.09	0.06	0.06		0.08
Sodium, %	avg	0.03 (24)	0.01 (3)	0.04 (47)	0.02	0.03 (84)
	range	0.01-0.17	.01-.02	0.01-0.15		0.00-0.17
	SD	0.03	.01	0.04		0.03
Iron, ppm	avg	205 (111)	169 (22)	224 (164)	27	212 (347)
	range	27-1037	70-653	18-1219		18-1219
	SD	144	122	200		173
Manganese, ppm	avg	179 (109)	145 (22)	175 (166)	17	171 (347)
	range	11-559	47-584	17-600		11-640
	SD	111	126	109		111
Copper, ppm	avg	10.9 (123)	8.8 (31)	11.4 (180)	0.8	10.9 (395)
	range	2.4-36.9	4.8-17.5	1.1-36.9		1.1-36.9
	SD	4.7	3.5	5.6		4.9
Zinc, ppm	avg	32.7 (111)	32.0 (22)	37.5 (166)	3.0	35.1 (350)
	range	9.0-91.1	13.5-65.9	5.5-184.5		5.50-184.5
	SD	14.2	14.3	20.5		17.4
Selenium, ppm	avg	0.06 (8)	0.04 (4)	0.09 (13)		0.08 (29)
	range	0.03-0.12	0.01-0.11	0.04-0.25		0.01-0.36
	SD	0.03	0.05	0.06		0.07

[1] All hays include the following species: alfalfa, alfalfa-grass mixtures, bahiagrass, bermudagrass, bluestem, bromegrass, clover, dallisgrass, fescue, johnsongrass, legume-grass mixtures, mixed grass, native grass, oat, orchardgrass, rye, ryegrass, sorghum-sudangrass, sorghum, soybean, straw of small grain, triticale, and wheat.

[2] Average value. All nutrient values except dry matter are shown on a dry-matter basis.

[3] Number of hay samples included in the average.

[4] Lowest value to highest value.

[5] Standard deviation.

[a,b,c] Means within rows without a common superscript differ (P<.05).

Table 2. Nutrient requirements of diets for beef cows and calves[1].

Nutrient	Dry, gestating cow[2]	Lactating cow[3]	Weaned calf[4]
Dry matter, lb/day	22.5	26.4	12.6
Crude protein, %	7.7	10.9	11.2
TDN,%	52.1	60.4	63.0
Calcium, %	.25	.31	.43
Phosphorus, %	.16	.21	.22
Potassium, %	.60	.70	.60
Magnesium, %	.12	.20	.10
Sulfur, %	.15	.15	.15
Sodium, %	.08	.10	.08
Iron, ppm	50	50	50
Manganese, ppm	40	40	40
Zinc, ppm	30	30	30
Copper, ppm	10	10	10
Selenium, ppm	.10	.10	.10

[1] All values except dry matter are shown on a dry-matter basis.
[2] 1100 lb dry, gestating cow, 11 months since calving.
[3] 1100 lb lactating cow, 2 months since calving, 20 lb peak milk
[4] 500 lb weaned calf, 1.5 lb ADG

Table 3. Percentage of hay samples deficient in crude protein, total digestible nutrients and mineral content for cows and calves.[1]

Item (No. samples)	Dry, gestating cow[2]	Lactating cow[3]	Growing calf[4]
Crude protein (5996)	12	42	46
Total digestible nutrients (5949)	28	72	83
Calcium (585)	5	10	26
Phosphorus (586)	10	18	20
Potassium (540)	<1	1	<1
Magnesium (552)	3	29	<1
Sulfur (518)	8	8	8
Sodium (84)	88	93	88
Iron (347)	4	4	4
Manganese (347)	3	3	3
Zinc (350)	44	44	44
Copper (395)	50	50	50
Selenium (29)	73	73	73

[1] Includes all hay samples.
[2] 1100 lb dry, gestating cow, 11 months since calving.
[3] 1100 lb lactating cow, 2 months since calving, 20 lb peak milk.
[4] 500 lb weaned calf, 1.5 lb ADG.

A Summary of 1998 Hay Production Costs for Three Farms Enrolled in the Arkansas Beef Improvement Program Hay Quality Project

Shane Gadberry, John Jennings, Gerald Van Brunt, Jennifer Hawkins, Tommy Thompson, and Tom Troxel[1]

Story in Brief

The Hay Quality Project of the Arkansas Beef Improvement Program (ABIP) was developed in 1998 to assist producers with improving hay quality, thereby reducing the need for additional supplements. Three producers completed the first year of a two-year commitment in 1998. The project required each producer to complete a hay production enterprise budget. In 1998, the average cost of producing a 1,000-lb bale at 88% dry matter was $37.49. Fixed costs and fertilizer accounted for 34.7 and 44.7% of the total cost per bale. From April through August, total rainfall was six and one-half inches below average, and from May to August, monthly temperatures were three degrees above average. In addition, two of the three farms were also infested with armyworms. Drought and armyworms elevated the cost of hay production during 1998 by suppressing yields.

Introduction

The majority of beef cattle producers in Arkansas rely on stored forage to feed the herd during winter months. Today, stored forage is typically harvested as hay packaged in large round bales. Many producers desire to own harvesting equipment and harvest the forage themselves, rather than relying on custom harvesting operations or purchasing the hay elsewhere. Unfortunately, there is limited information available to producers in Arkansas on harvesting costs. In some cases, lesser quality hay is produced because of delays by custom harvesters; however, supplementing these forages with other feedstuffs may still be less expensive than owning the forage harvesting equipment.

As part of the ABIP hay quality project, producers were required to complete a hay production budget. A summary of the budgets from these farms provides Arkansas cattle producers with a source of information about the costs of harvesting forage as hay.

Experimental Procedures

In the fall of 1997, ABIP project application forms were mailed to all county extension offices. In February 1998, three producers were selected to participate in the two-year project. Data collected on each field enrolled in the project included a soil analysis, field acreage, field inventories, precipitation records, fertilization records, harvest dates, bale weights, and forage quality analyses.

At the end of the haying season, a hay production budget was completed on each farm. All three producers owned their own equipment. Equipment age varied across farms and ranged from 2 to 15 years. One producer was a custom harvester and charged his custom haying rate to his own hay enterprise budget. A 12-year straight-line depreciation was used for calculating equipment costs on the other two farms.

To compare costs across farms, the costs of production for each farm were based on average bale weight and moisture content for hay produced on each farm and adjusted to a 1,000 lb bale at 88% dry matter. Fixed cost items in the budget included depreciation for haying equipment (rake, mower, tedder), 50% of tractor depreciation, insurance, personal property taxes, and interest on equipment. Land purchase, rental costs or real property taxes were not included in the budget. Direct costs included any custom haying hired; fuel, oil, and lubrication; repairs and maintenance; twine or wrap, fertilizer, lime, chemicals, hired labor, and establishment costs for any newly established hay fields.

A break-even value for hiring a custom harvester was determined by the summation of the fixed costs; fuel, oil, and lube; repairs and maintenance; and twine and wrap expenses. Neither the producer's labor for harvesting and hauling nor the cost of equipment and hay storage were included in the budget.

Results and Discussion

The total acreage harvested across the three hay quality project farms averaged 204 acres (SE = 108). One of the three producers harvested forage for hay one time during the year. The producer's hay meadow was predominately orchardgrass and fescue. The other two producers relied predominately on multiple cuttings of bermudagrass to ac-

[1] All authors are associated with the Animal Science Section, Cooperative Extension Service, Little Rock

quire enough hay to carry the herd throughout the winter months.

In 1998, the average rainfall accumulation from April to August was 6.5 in below the National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center historical 57-yr rainfall average. The NOAA rainfall data was reported from within the counties where participants resided. From May to August, monthly temperatures averaged 3.1° higher than a 15-year NOAA historical temperature average for Arkansas. Along with drought in 1998, armyworm infestation reduced total hay yield on one project farm. Compared to the number of bales produced in 1997, the producer suffered an 18.6% loss in hay production due to drought and armyworms. The average dry matter yield across farms was 0.79 tons per acre. The average number of bales produced was 442; these bales averaged 791 lb per bale. The number of round bales produced, adjusted to a 1,000 lb standard weight at 88% dry matter, averaged 397 bales across the three farms.

The hay produced on the three farms averaged 12.7% (SE = 2.7) crude protein and 58.8% (SE = 5.4) TDN on a dry matter basis. The average quality was high enough to meet the nutritional demands of a 1,100-lb cow producing 10 lb of milk during peak lactation at 2 months post calving.

The cost of producing a 1,000 lb round bale at 88% dry matter averaged $37.49 (SE = 9.01). Fixed costs averaged $14.69 per bale (SE = 3.00) for two farms that reported equipment costs using a 12-year straight-line depreciation. Fixed costs accounted for an average of 34.7% of the total cost per bale. Fertilizer cost averaged $16.88/bale (SE = 4.67) and contributed 44.7% to the total cost per bale among the three farms. Twine and wrap cost averaged $1.08/bale (SE = 0.55). Chemical (herbicide and insecticide) cost averaged $3.20/bale (SE = 3.41).

Break-even cost on custom baling was calculated on the two farms that reported equipment depreciation. The average break-even value was $14.15 and $20.86/bale. If custom baling charges per bale, adjusted to a 1,000 lb bale at 88% dry matter, were acquired for less than the break-even value, then it would be cheaper to pay someone to harvest the hay than to invest in the equipment and operating costs, not including labor.

In 1998, low hay yields were common in Arkansas due to drought and armyworms. These conditions affected the cost of producing a bale of hay. As yields increase, direct costs such as twine and fuel will increase, but on a cost per bale basis, they should remain about the same. Fixed costs, however, do not change with production; therefore, producing more bales should reduce the fixed cost per bale. Since yields were less than anticipated in 1998, cost per bale was higher because the fixed costs were distributed over fewer bales. Fertilizer cost per bale was also higher than expected. Each producer fertilized according to soil test recommendations for high yields, which were not achieved due to insufficient precipitation.

In spite of the drought, these producers cut hay for quality instead of just quantity. The average cost per hundred pounds of TDN baled (dry matter basis) was $7.20 (SE = 1.45). The cost of 100 lb of TDN from sacked cracked corn was $10.50 in February 1999.

Overall, 1998 was not an ideal year to illustrate the typical cost of producing a bale of hay in Arkansas. Over time, as more farms participate in the project and year-to-year variations in environment are removed, more typical cost figures can be obtained.

Implications

Beef cattle producers prefer the convenience of owning haying equipment. Ownership gives a producer more control over the quality of hay produced; however, in some situations, the cost of owning and operating haying equipment is more expensive than supplementing lesser quality hay. Producers must consider equipment and operating costs involved in producing hay and evaluate sources of farm income from sales of livestock and excess hay to justify owning haying equipment.

Storage Characteristics of Bermudagrass Hay as Affected by Moisture Content and Density of Square Bales

W.K. Coblentz, J.E. Turner, D.A. Scarbrough, K.E. Lesmeister, D.W. Kellogg, K.P. Coffey, L.J. McBeth, and J.S. Weyers[1]

Story in Brief

Bermudagrass was packaged in small square hay bales at five moisture concentrations (32.5, 28.7, 24.8, 20.8, and 17.8%) and two bale densities (high and low). Bale moisture dramatically affected storage characteristics, but bale density did not. This may not have been true if larger differentials between high and low bale densities were used. Most evidence of heating occurred within the first 20 days of storage. Generally, this study suggests that maximum temperatures > 140°F are readily attainable in conventional small square bales of bermudagrass hay made at high concentrations of moisture. Minimal dry matter loss and mold development will occur in bermudagrass hay if the moisture concentration at baling is < 20%. Further evaluation of these characteristics in large round bales is needed; it should not be assumed that the relationships illustrated by this study can be extrapolated to larger bale types.

Introduction

The harvest, storage, and cash sale of improved varieties of bermudagrass hay is a large component of the cattle and horse industries in northwest Arkansas. The production of these intensely managed bermudagrass hays is largely driven by readily available poultry litter that serves as an inexpensive source of fertilizer. Producers who package their hay in conventional, small square bales routinely receive $140/ton for this product. Prevailing weather conditions throughout Arkansas include high relative humidity and a relatively high probability of rainfall during portions of the time bermudagrass is actively growing and being harvested. Producers are often faced with the choice of baling before adequate dessication has occurred or subjecting their crop to rain damage. The negative storage characteristics and quality changes that occur when alfalfa hay is baled at moisture concentrations >20% are well documented. Considerably less information is available concerning storage characteristics and quality changes that occur in grass hays generally, and warm-season grass hays specifically. The objectives of this research were to examine the effects of initial bale moisture and density on spontaneous heating and storage characteristics of bermudagrass hay. A secondary objective was to relate dry matter loss and mold development that occurred during bale storage to maximum internal bale temperature and the heating degree days >95°F (HDD) accumulated during the same time period by linear regression techniques.

Experimental Procedures

Field Procedures. A well-established stand of 'Greenfield' bermudagrass was harvested with a John Deere Model 1219 mower-conditioner (John Deere Corp., Moline Illinois) on 15 June 1998 at the Forage Research Area in Fayetteville. The forage was mowed at 1000 hours in three blocks of 10 swaths each and allowed to dry, undisturbed, until 0930 hours on 16 June. At this time, two swaths were raked together with a New Holland Model 258 side-delivery rake (Ford New Holland, Inc., New Holland, Pennsylvania); therefore, a final total of five double rows per block remained after raking. Double-rows in each block were allocated randomly to one of five whole plots, based solely on moisture concentration at the time of baling. Double-rows were inverted an additional time at 1300 hours with the side delivery rake to enhance drying and to allow the inclusion of bales packaged at less than 20% moisture within the treatment structure. The subplot treatment factor for this study was bale density. Bale density has been shown to have significant effects on spontaneous heating characteristics in alfalfa hay bales (Buckmaster and Rotz, 1986; Coblentz et al., 1996). Two density treatments (high and low) were established within each moisture concentration. A New Holland Model 320 baler with hydraulic density control was used to package the bales. The ultimate goal in establishing the high moisture treatments was simply to make a very solid (dense) bale. The low density treatments were created by rotating the hydraulic valve that controls tension on the bale chamber by 1/2 revolution in a counter-clockwise direction.

Four bales (average size = 18.9 in x 15.0 in x 38.6 in) were made per field block for each combination of moisture concentration and bale density. The protocol for stacking hay bales was similar to that reported previously (Coblentz et al., 1996). Wooden pallets were placed on the dirt floor of an open-air pole shed; two bales from each group of four were positioned side by side (strings up) on top of the wooden

[1]All authors are associated with the Department of Animal Science, Fayetteville.

pallets. The remaining two bales from each set of four were positioned with the same orientation on top of the first two bales, thereby creating 2 x 2-bale stacks for each field replication of each treatment combination. Individual stacks containing four bales were surrounded by dry (nonheating) bales of weathered bermudagrass hay. The top of each individual stack was covered with a single, weighted sheet of 1.0-in thick Styrofoam® insulation board (Celotex Corporation, Tampa, Florida). This stacking protocol was designed to limit the effects of fluctuating ambient temperature within the individual experimental hay stacks. Stacks were created within two h of removal of bales from the field. Prior to creating treatment stacks, two of each set of four bales were core sampled (Star Quality Samplers, Edmonton, AB, Canada) to provide forage samples that were subsequently used to determine the initial bale moisture concentration of all treatment combinations. At least two 14-in cores were taken from the butt-ends of each bale. One cored bale was placed on the top and bottom layer of each bale stack. Core samples were dried to constant weight under forced air at 122°F.

All bales entering storage were weighed and, due to time constraints, measured for length only. Prior to conducting this research it was determined that very little variability existed with respect to height and width of the bales produced by our baler. Respective averages for these measurements were 15.0 and 18.9 in and these values were assumed to be consistent throughout the trial. Bale volume (and subsequently, bale density) was calculated from the measured length of each bale and the predetermined values for height and width. For each stack, bale temperatures were monitored by inserting single thermocouples into the center of the two bales in each stack that were not core sampled prior to stacking (one in the top layer and the other in the bottom layer). Bale temperatures were recorded at 0700 and 1600 hours for the first 10 days after baling and once daily (at 1600 h) thereafter, until the end of the 60-day storage period. All temperature data were compiled with an Omega 450 AKT Type K thermocouple thermometer (Omega Engineering, Stamford, Connecticut). For purposes of computation, the mean internal bale temperature for a given day was considered to be the same as the observed temperature, except during the first 10 days, when the mean of the two observations was used. Degree days >95°F (HDD) were computed as the summations of the daily increment by which the mean internal bale temperature was >95°F. Treatment means were compared for maximum temperature, minimum temperature, 30-day average temperature, 60-day average temperature, and HDD. Several previous studies have used 86°F as the threshold temperature level for calculating HDD; however, the 60-day storage period lasted from mid-June until mid-August and coincided with prolonged, excessively hot weather. Ambient temperatures approached 110°F on numerous occasions during this time period; therefore, a higher arbitrary threshold was used to calculate HDD, thereby limiting the effects of elevated ambient temperatures on the HDD accumulated during storage.

After 60 days of bale storage, all bales that were monitored daily for internal bale temperature were core sampled (two from each stack) in a manner identical to that described previously and then visually appraised for mold growth (five point scale: 1 = no visible mold, 2 = presence of spores between flakes, 3 = presence of spores throughout bale, 4 = mycelial mat between flakes, and 5 = mycelial mat throughout the bale) by the method of Roberts et al. (1987). When appropriate, increments of 0.25 were used to evaluate each bale. Dry matter recoveries for all stacked bales were determined from calculated DM weights of each bale before and after storage.

Statistical Analysis. All response variables were analyzed as a split-plot design with five moisture concentrations as whole plots and two bale densities as the subplot treatment factor. Three replications (blocks) were established in the field and maintained throughout the storage period. Actual treatment means were compared using Fisher's protected least significant difference test. Significance was declared at $P = .05$; all references to statistical significance imply this level of confidence unless otherwise indicated. The relationship between visual mold score and dry matter recovery in treatment bales and associated measures of heating (maximum temperature and HDD) was determined by linear regression techniques.

Results and Discussion

Bale Characteristics. Bale characteristics for ten combinations of bale moisture and density are shown in Table 1. For these treatment combinations, moisture concentrations ranged between 16.9 and 33.6% and (wet) bale densities ranged from 9.2 to 15.1 lb/ft^3, which created a wide range of responses with respect to spontaneous heating, mold development, and dry matter loss (Table 2). On both a dry and wet basis, moisture and density main effects significantly ($P \leq .002$) affected the actual weight and density of our treatment bales; however, the interaction of factors was not significant ($P \geq .196$). Conversely, the length and volume of our treatment bales was not affected by the moisture ($P \geq .37$) or density ($P \geq .73$) treatment factors, but their interaction term was significant ($P = .020$). Generally, the procedures used in this study were adequate to generate statistically significant ($P < .05$) differences in bale weight and bale density on both a dry and wet basis for bales made within a given moisture level, but at different (high or low) bale densities.

Temperature Responses. Examples of temperature vs. time curves for three baling treatments (Fig. 1) indicate that spontaneous heating began immediately after packaging and continued for about 15 to 20 days. Little evidence of spontaneous heating was observed after 20 days in storage. Initial bale moisture had a highly significant ($P < .02$) effect on indices of spontaneous heating in bermudagrass hay bales. Although bale density (high or low) significantly affected initial bale weight and density on both a wet and dry basis, this treatment factor did not affect ($P \geq .21$) indices of heating. The interaction of main effects was also nonsignificant

($P \geq .196$); therefore, data were combined over high and low bale densities and only moisture means are presented in Table 2. (This was also true for visual mold and dry matter recovery and these data were presented in a similar manner.) There were no differences ($P > .05$) in any index of heating between bales made at the two highest moisture concentrations (32.5 and 28.7%). As expected, all measures of heating declined ($P < .05$) in bales made at the three lowest moisture concentrations (24.8, 20.8, and 17.8%). Generally, this study suggests that maximum temperatures > 140°F are readily attainable in conventional small square bales of bermudagrass hay made at high concentrations of moisture. Even in the driest treatment (17.8%), measurable increases in internal bale temperatures were observed. However, these indications of respiration and spontaneous heating were relatively small and have not normally caused substantial changes in forage quality when observed in other types of hay (Coblentz et al., 1996). The HDD accumulated during storage can be viewed as a single numerical value that represents and combines both the intensity and duration of spontaneous heating in hay. As suggested by the maximum temperature, as well as the 30-day average, the wettest hays (32.5 and 28.7% moisture) exhibited a more intense and prolonged period of heating than did the drier treatments. These characteristics have been shown to be even more pronounced in large round hay packages (Montgomery et al., 1986).

Visible Mold. The method used to evaluate mold development is based on a five-point scale. In this scale, a score of 1.00 would represent a bale that had no visible signs of mold and had no musty or other heat-related odors. A score of 5.00 would represent a bale that had visible white mold throughout all bale flakes. The maximum mold score observed in this study was 3.73, which indicated substantial evidence of mold devlopment; this included discoloration, dustiness, obvious musty odor, and the presence of white mold between some bale flakes. In contrast, the mold score of the driest hay (1.13), reflects hay with virtually no evidence of undesirable microbial activity. In this study, the visible mold scores declined ($P < .05$) as moisture content decreased. This observation has been commonly observed in other studies and reflects the less-favorable environment for microbial growth that exists within hay bales made at low moisture concentrations (< 20%).

Dry Matter Recovery. When hay bales are packaged at elevated moisture concentrations, plant sugars and other highly digestible components are respired by microorganisms, thereby generating heat. The respiration of these plant components results in a loss of dry matter. Dry hay creates a less favorable environment for microbial growth, resulting in less loss of plant dry matter via respiration. In this study, dry matter loss ranged from about 6% to near total recovery in the driest hay.

Regression of Visible Mold and Dry Matter Recovery on Heating Degree Days and Maximum Temperature. Both mold development and dry matter recovery are closely related to indices that reflect the relative amount of spontaneous heating that occurs within hay bales. In this study, estimates of visible mold development and dry matter recovery were regressed on HDD and maximum temperature (Figs. 2 through 5); in all cases, these relationships demonstrated high ($\geq .86$) r^2 statistics, thereby verifying close relationships between these storage characteristics. These findings suggest that visual mold may increase by 0.6 units for every 10°F increase in maximum temperature; conversely, dry matter recovery will decrease by 1.3% for every increase of 10°F in maximum temperature.

Implications

This study shows that moisture content at baling has a dramatic effect on characteristics of spontaneous heating. Most evidence of heating occurred within the first 20 days of storage. Generally, this study suggests that maximum temperatures > 140°F are easily attainable in conventional small square bales of bermudagrass hay. Minimal dry matter loss and mold development will occur in bermudagrass hay if moisture content at baling is < 20%. Further evaluation of these characteristics in large round bales is needed; it should not be assumed that the relationships illustrated by this study can be extrapolated to larger bale types.

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Table 1. Bale characteristics of bermudagrass hay made at five concentrations of moisture and at high (H) and (L) densities.

Moisture level	Density level	Bailing time	Moisture content	Bale length	Bale volume	Initial bale weight (wet)	Initial bale density (wet)	Initial bale weight (dry)	Initial bale density (dry)
		h	%	ft	ft^3	lb	lb ft^{-3}	lb DM	lb DM ft^{-3}
1	H	09:45	31.3	3.14	6.23	94.0	15.1	64.4	10.4
	L		33.6	3.43	6.76	91.3	13.5	60.6	9.0
2	H	10:55	27.7	3.15	6.23	92.5	14.8	66.9	10.7
	L		29.8	3.13	6.19	85.1	13.7	59.7	9.6
3	H	12:15	26.6	3.22	6.37	86.8	13.6	63.7	10.0
	L		22.9	3.18	6.30	73.6	11.7	56.5	9.0
4	H	14:30	21.1	3.25	6.44	70.2	10.9	55.3	8.6
	L		20.5	3.21	6.34	60.8	9.6	48.3	7.6
5	H	16:45	16.9	3.29	6.51	66.2	10.1	54.9	8.4
	L		18.7	3.17	6.27	57.6	9.2	46.6	7.4
		LSD (0.05)[1]	5.2	0.16	0.32	6.2	1.4	3.3	0.7

[1] LSD (.05) = least significant difference for comparing bale densities within moisture levels.

Table 2. Heating and storage characteristics of bermudagrass hay made at five concentrations of moisture.

Moisture level	Initial moisture content		MAX[1]	MIN[1]	30-day AVG[1]	60-day AVG1	HDD> 95°F[1]	Visible mold[2]	Dry matter recovery
	%		°F	°F	°F	°F	no.		%
1	32.5		143.2[a]	88.5[a]	113.9[a]	103.6[a]	589[a]	3.73[a]	94.1[c]
2	28.7		139.1[a]	88.0[ab]	113.5[a]	103.5[a]	583[a]	2.69[b]	94.0[c]
3	24.8		129.6[b]	86.5[bc]	108.1[a]	100.2[b]	419[b]	2.19[b]	95.1[bc]
4	20.8		110.3[c]	86.2[c]	99.9[b]	95.7[c]	184[c]	1.54[c]	97.3[ab]
5	17.8		104.4[d]	86.0[c]	96.6[b]	93.7[c]	99[c]	1.13[c]	99.4[a]
		SE[3]	4.0	0.7	2.5	1.4	63	0.23	1.2

[a, b, c, d] Means within a column that have no common superscripts differ (P<0.05).

[1] Abbreviations: MAX = maximum temperature, MIN = minimum temperature, 30-day AVG = average temperature over the first 30 days of storage, and 60-day AVG = average temperature over the entire (60-day) storage period, HDD > 95°F = heating degree days > 95°F.

[2] Visible mold assessment score (1 = good, 5 = poor).

[3] Standard error of the difference between moisture means.

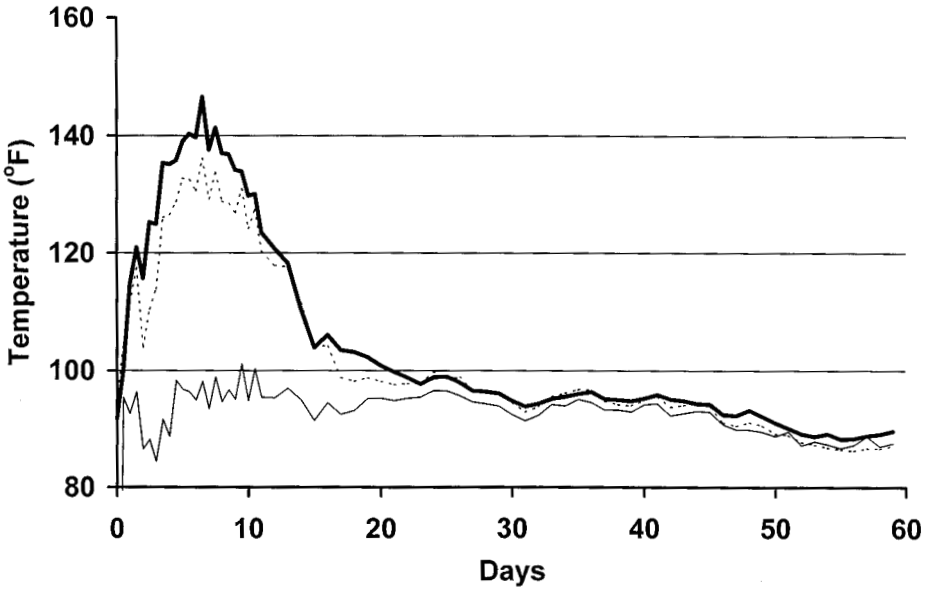

Fig. 1. Examples of temperature vs. time curves for three high-density baling treatments. Heavy solid, light dashed, and light solid lines correspond to bales made at 31.3, 26.6, and 16.9% moisture, respectively.

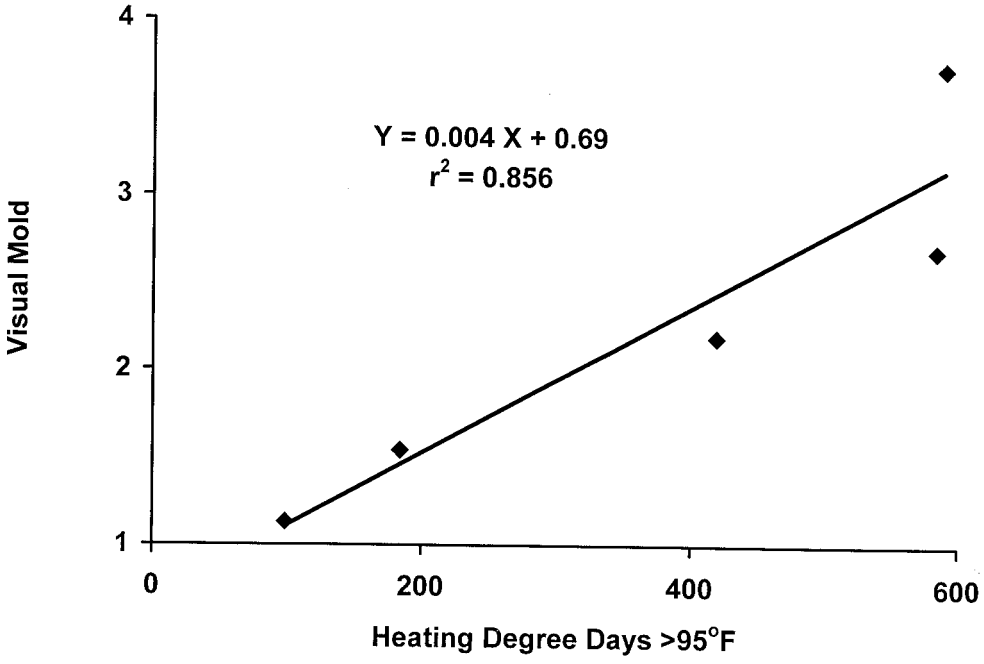

Fig. 2. Relationship between visual mold and HDD for conventional bermudagrass hay bales made at five moisture concentrations.

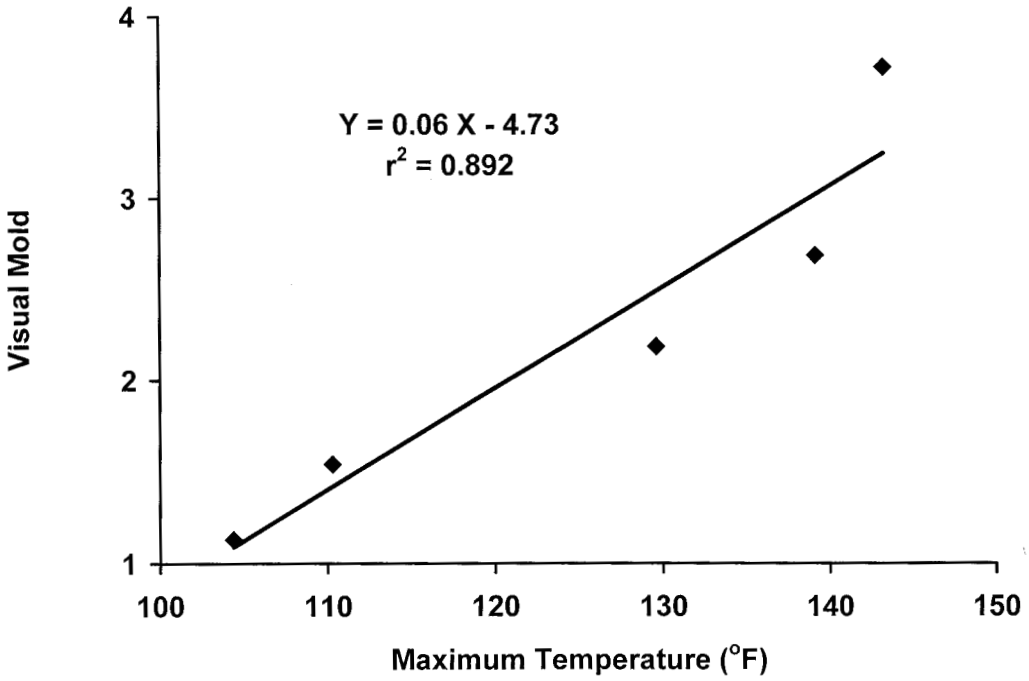

Fig. 3. Relationship between visual mold and maximum internal bale temperature for conventional bermudagrass hay bales made at five moisture concentrations.

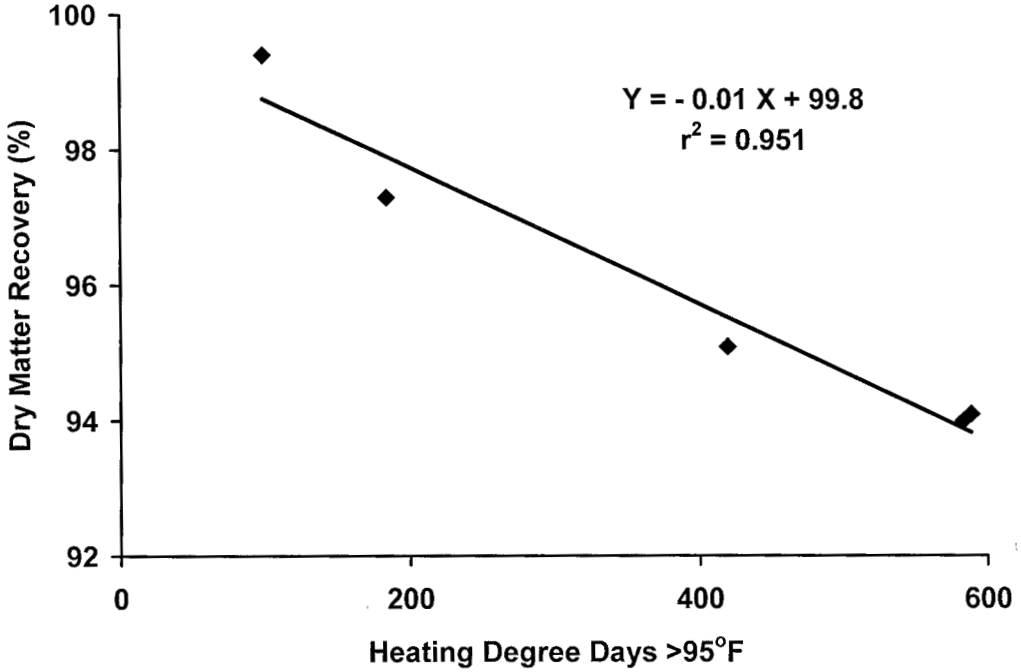

Fig. 4. Relationship between dry matter recovery and HDD for conventional bermudagrass hay bales made at five moisture concentrations.

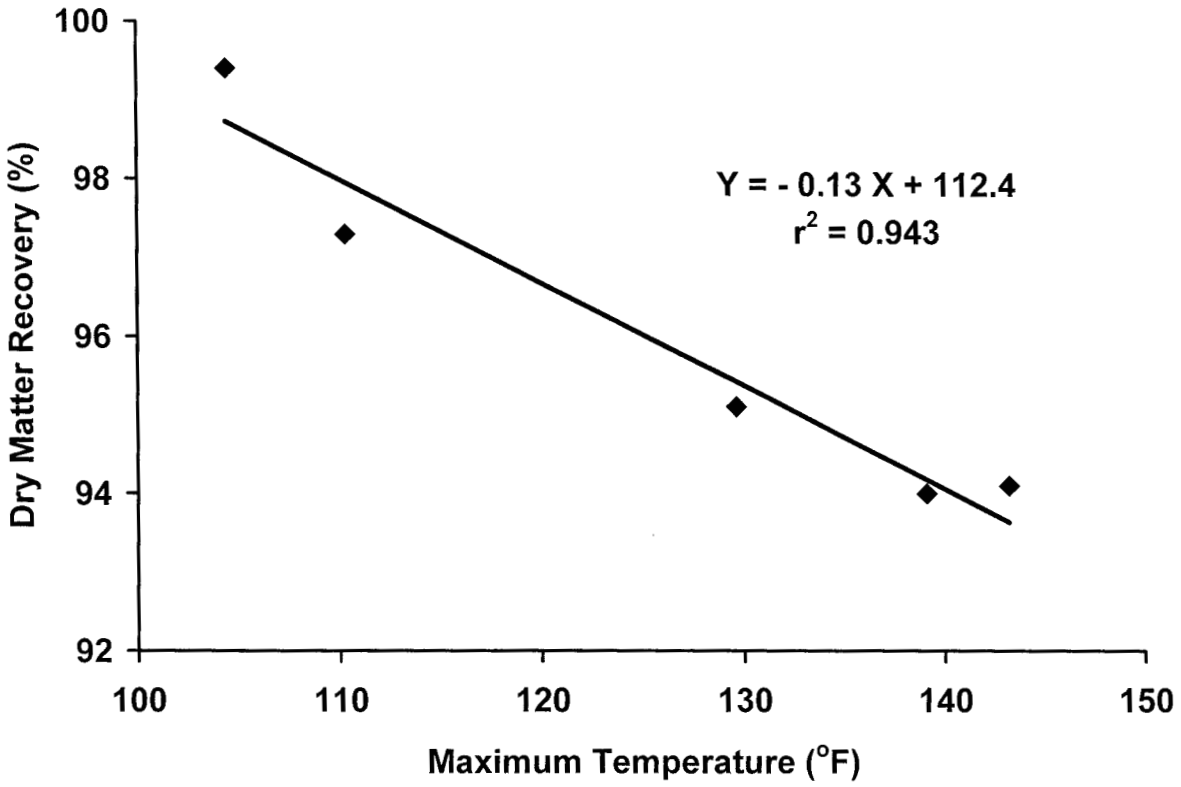

Fig. 5. Relationship between dry matter recovery and maximum internal bale temperature for conventional bermudagrass hay bales made at five moisture concentrations.

Evaluation of Seeding Rate and Herbicide Treatment on Growth and Development of Sod-Seeded Oat, Wheat, and Rye

W.K. Coblentz[1], K.P. Coffey[1], J.E. Turner[1], K.F Harrison[2], L.B. Daniels[1], C.F. Rosenkrans, Jr.[1], and D.S. Hubbell, III[2]

Story in Brief

Wheat, rye, and oat were overseeded into a bermudagrass sod in the fall of 1997. Herbicide (glyphosate[3]) treatment to suppress the existing bermudagrass sod and/or increased seeding rates failed to improve forage production in the fall, winter, and early spring. However, these results suggest that total forage dry matter yields of 4000 lbs/acre are realistic for overseeded cereal grains in northern Arkansas. The limited fall and winter growth severely restricts the cost-competitiveness of overseeded cereal grains for cow-calf production, relative to reliance on perennial cool season grasses. This practice may be more appropriate in northern Arkansas for producers interested in a single mechanical harvest as silage or hay.

Introduction

The overseeding of bermudagrass pastures with winter annual cereal grains has been a common practice throughout Arkansas. The system works well in southern Arkansas because the climate is favorable for some continued growth throughout the late fall and winter and other options for cool-season perennial forages are limited. Some overseeding of bermudagrass is regularly attempted in northern Arkansas, but adequate growth to support intense cattle enterprises can't be guaranteed until at least mid-March. By then, tall fescue, which is the dominant forage type in northern Arkansas, or other cool-season perennials are readily available. In addition, the costs associated with overseeding most winter annuals are likely to result in higher production costs than those incurred with continued use of tall fescue in cow-calf systems. The most fertile and tillable land throughout northern Arkansas is frequently used for production of hybrid or improved bermudagrass, often for cash sale. Despite the limitations described, many producers would actively consider increased usage of overseeded cereal grains on these sites for stocker, dairy heifer, and/or cow-calf enterprises if sod suppression techniques could be developed that would allow fall growth of cereal grains comparable to that described in clean-tilled seedbeds. Recent studies in Louisiana (Cuomo and Blouin, 1997) have suggested that fall production of sod-seeded annual ryegrass can be improved by application of glyphosate in conjunction with sod seeding. Aggressive fall growth of sod-seeded winter cereal grains would improve cost-competitiveness with tall fescue and other cool-season perennials. The objectives of this study were to evaluate the effects of seeding rate and sod suppression with glyphosate on the growth and development of sod-seeded wheat, oat, and rye.

Experimental Procedures

Establishment. This study was conducted at the Batesville Livestock and Forestry Branch Station located near Batesville, AR. A 200 by 92-ft plot area was established on a Peridge silt loam. The base sod at this site was a well-established stand of 'Tifton 44' bermudagrass that was harvested as hay in mid-August. Regrowth following haying was limited because of droughty weather conditions. No further removal of existing vegetation was attempted prior to establishing the study. Existing vegetation at the experimental site was estimated by clipping all vegetation (alive and dead) within four 1/4-m^2 frames selected from random locations throughout the site. The mean residual plant dry matter was calculated to be 213 lb/acre. Prior to establishing the plots, the site was fertilized to soil test recommendations for fall-seeded cereal grains. The study was established in a split-plot design with herbicide treatment (1 quart glyphosate per acre or no herbicide treatment) as the whole-plot treatments. The subplot treatment structure was a 3 x 2 factorial combination of cereal grain species (oat, wheat, and rye) and seeding rate (low and high). The low seeding rates were set at 90, 90, and 96 lb of pure live seed per acre for wheat, rye, and oat, respectively. High seeding rates were increased by 50% relative to the low rate; therefore, respective rates for these species were 135, 135, and 144 lb of pure live seed per acre. Cereal grain varieties selected for this study included 'Jay

[1] Department of Animal Science, Fayetteville.
[2] Livestock and Forestry Branch Experiment Station, Batesville.
[3] Roundup Ultra® (Monsanto Company, St. Louis, Missouri, 63167).

Pee' wheat, 'Elbon' rye, and 'Ozark' oats. Plots were sprayed, and then drilled in 10-inch rows with a 80-inch wide Tye Pasture Pleaser Drill (The Tye Company, Lockney, Texas) on September 24, 1997. Individual subplots were drilled with a single drill pass. Subplot length was 30 ft. All plots were fertilized with an additional 50 lb of nitrogen per acre on 14 February 1998. Four replications (blocks) were established for all treatment combinations.

Fall Evaluation. In conducting this study, our goal was to reduce the competitiveness of the bermudagrass sod with application of glyphosate herbicide, thereby potentially improving establishment and fall growth characteristics of the cereal grains. A 56-day withholding period for grazing livestock is required following application of glyphosate to established pastures; therefore, the initial fall evaluation was conducted 56 days after herbicide treatment (20 November 1997). Row coverage was determined for each plot by placing a tape measure (divided in tenths of feet) between two randomly selected drill rows and tabulating blank spaces for both adjacent rows over a 20-ft distance. Percentage of row coverage was calculated as: coverage (%) = 100 - ([blank spaces {ft} / 20 ft] x 100). Percent row coverage for the two rows adjacent to the tape measure were averaged prior to statistical analysis. It was our initial intention to determine fall forage production for these cereal grains at this time; but, visual inspection of the plots indicated that fall forage production was not improved by any of the treatments in this study. For this reason, the evaluation of forage dry matter yield was delayed until spring.

Spring Evaluation. During the spring of 1998, forage dry matter yield was determined for each plot on five dates at three-week intervals (4 March, 24 March, 15 April, 4 May, and 26 May). Forage yield of cereal grains was determined by clipping two 1/4-m^2 frames within each plot. Undesirable species were removed in the field. Cereal grains were harvested with hand shears at an approximate one-inch cutting height. Clipped forage was dried to constant weight at 50°C and dry matter yield was determined by applying appropriate conversion factors. On each clipping date, three representative plants within each plot were measured for height and evaluated for growth stage using a linear scale (Stauss, 1994; see Table 1). Forage dry matter yield, growth stage, and plant height were evaluated as a split-plot design with repeated measures. However, sources of variation that included seeding rate and/or herbicide treatment were consistently nonsignificant ($P > .05$). Therefore, these terms were dropped from the analysis. An independent randomized complete block analysis was conducted subsequently for each cereal grain with harvest date as the treatment factor. Linear regression techniques were used to evaluate the relationship between plant height and yield for each cereal grain.

Results and Discussion

Fall Row Coverage. Fall row coverage was generally good (overall mean = 79.4%) for all treatment combinations. Increasing seeding rate did not improve row coverage in the fall ($P > .05$). Herbicide treatment improved fall row coverage ($P < .05$); however, the interaction of herbicide treatment and forage species (Table 2) was significant ($P = .018$). When herbicide was applied to the bermudagrass sod at establishment, fall row coverage of oat, wheat, and rye did not differ (overall mean = 83.5%). Without herbicide treatment, oat displayed the best row coverage (86.7%), which was significantly greater than that of wheat (64.8%). Row coverage for rye was intermediate between the other forage species, but did not differ significantly from either.

Growth Stage. For all three forage species, there were only minor changes in plant maturity between the 4 March and 24 March harvest dates (Table 3). During this time period, below-freezing temperatures may have limited plant development. Beginning on 24 March, plant maturity for each cereal grain increased ($P < .05$) during each three-week sampling interval; although, rye matured faster than the other forages, particularly oat. This was especially evident on April 15, when the inflorescence of rye was fully emerged. On the same date, the tip of inflorescence was just beginning to emerge in wheat plants, while oat plants were just entering boot stage. By 4 May, growth stages of rye and wheat were identical; in both species, grains were beginning to fill following anthesis. The inflorescence of oat was fully emerged on this date, thereby representing a 19-day delay reaching this stage of development, relative to rye. On 26 May, both rye and wheat had reached the early dough stages of grain development, but oat grains were still exhibiting a milky character.

Plant Height. Cereal rye has a substantially taller growth habit than either wheat or oat (Table 3). Rye reached a maximum height (57.4 inches) that was more than twice that of wheat (26.7 inches). Both rye and wheat reached their maximum height on the May 4 harvest date, but oat plants grew about 7.5 inches ($P < .05$) between 4 May and 26 May, thereby illustrating the slower development characteristics of oat.

Forage Yield. Forage dry matter yields for rye, wheat, and oat are shown in Table 3. The freezing weather conditions (< 10°F) that occurred between the 4 March and 24 March harvest dates had a dramatic effect on wheat yields. Final dry matter yields for wheat on 26 May were only 48.5 and 59.6% of those for rye and oat, respectively. There was also a noticeable thinning of wheat stands in association with this severe cold period. Rye (which is known to be cold tolerant) and oat plots did not appear to be thinned by March weather conditions. The rapid development of cereal rye was evident in the distribution of dry matter production. Rye accumulated 50.7% of its total dry matter production by April 15. This contrasted sharply with oat, which accumulated only 41.2% of its total dry matter production by this date. Based on this work, it appears that total yields of 4000 lb/acre are realistic for sod-seeded cereal grains in northern Arkansas. However, these yields are weather dependent. Most importantly, none of the treatments included in this study facilitated accumulation of dry matter in the fall. By 24 March, no cereal grain had produced more than 750 lb/acre of for-

age dry matter. The severe cold during mid-March may have contributed to this apparent slow development, but it is clear that the establishment techniques evaluated in this study did not allow sufficient dry matter production in the fall, winter, and early spring to support intense livestock enterprises.

Relationship Between Forage Height and Forage Yield. Forage availability can be managed more easily by producers if it can be estimated from other measurements that are quickly obtained. The simplest method to estimate forage availability is to measure plant height with a ruler and then convert height to lbs/acre. Therefore, forages that exhibit close relationships between plant height and forage availability are often easier to manage in a pasture setting than forage crops that exhibit poor relationships between these characteristics. For each cereal grain, forage yield data at each harvest date was regressed on the corresponding plant height on that same date (Table 4). A total of 80 observations were included in each regression (16 observations/species/harvest date). Slopes ranged from a low of 88 lb/in for rye up to 119 lb/in for oat; however, these parameter estimates were not different ($P > .05$). Intercepts for each species differed ($P < .05$), and all intercepts were negative (range = -229 to -640 lb/acre). The r^2 statistics ranged from .54 to .67, indicating that about 54 to 67% of the variability in yield across the five harvest dates could be explained on the basis of plant height alone. Much of the variability not explained by plant height is probably associated with grain development. This process added considerably to forage dry matter yield after the plants had reached their maximum height. This trend was particularly evident for rye and wheat harvested between 4 May and 26 May. This research suggests that there is an increase of about 100 lb of forage dry matter per acre for every inch of plant height.

Implications

These findings suggest that total forage dry matter yields of 4000 lb/acre are realistic for overseeded cereal grains in northern Arkansas. Unfortunately, this growth is primarily restricted to the period between mid-March and early June. Application of glyphosate at seeding and/or increased seeding rates did not improve the accumulation of forage dry matter during the fall, winter, or early spring. This severely restricts the cost-competitiveness of overseeded cereal grains for cow-calf production, relative to perennial cool season grasses. This practice may be more appropriate in northern Arkansas for producers interested in a single mechanical harvest as silage or hay. These results represent the growth characteristics during the 1998 growing season in northern Arkansas. Caution should be used when using these results to estimate growth/yield potential for other varieties, growing seasons, or locations.

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Stauss, R. 1994. Compendium of growth stage identification keys for mono- and dicotyledonous plants. Extended BBCH scale. Compiled by Reinhold Stauss. Ciba-Geigy AG, Basel, Switzerland.

Table 1. BBCH (European) uniform decimal code for describing morphological development of cereal crops (Stauss, 1994).

Code	Morphological descriptor
Principal growth stage 1: leaf development	
10	first leaf through coleoptile
11 to 18	leaves 1 to 8 unfolded
19	9 or more leaves unfolded
Principal growth stage 2: tillering	
20	no tillers
21	beginning of tillering, first tiller detectable
22 to 28	2 to 8 tillers detectable
29	9 or more tillers detectable
Principal growth stage 3: stem elongation	
30	beginning of stem elongation
31	first node at least 1 cm above tillering node
32 to 38	nodes 2 to 8 detectable
Principal growth stage 4: booting	
41	early boot stage, flag leaf sheath extended
43	midboot stage, flag leaf sheath just visibly swollen
45	late boot stage, flag leaf sheath swollen
47	flag leaf sheath opening
49	first awns visible
Principal growth stage 5: heading	
51	tip of inflorescence emerged from sheath, first spikelet just visible
53	30% of inflorescence emerged
55	50% of inflorescence emerged
57	70% of inflorescence emerged
59	inflorescence fully emerged
Principal growth stage 6: flowering, anthesis	
61	beginning of flowering, first anthers visible
65	full flowering, 50% of anthers mature
69	end of flowering, all spikelets have completed flowering but some dehydrated anthers may remain
Principal growth stage 7: development of fruit	
71	watery ripe, first grains have reached half their final size
73	early milk
75	medium milk, grain content milky, grains final size, but still green
77	late milk
Principal growth stage 8: ripening	
83	early dough
85	soft dough, grain content soft but dry, fingernail impression not held
87	hard dough, grain content solid, fingernail impression hard
89	fully ripe, grain hard, difficult to divide with a thumbnail
Principal growth stage 9	
92	over-ripe, grain very hard, cannot be dented by thumbnail
93	grains loosening in day time
97	plant dead and collapsing
99	harvested product

Table 2. Fall row coverage for forage species by herbicide treatment interaction means of fall sod-seeded winter annuals at Batesville in 1997[1]. Herbicide treatment was applied as glyphosate at a rate of one quart per acre.

Forage species	Herbicide treatment	
	No herbicide	Herbicide
	----------%----------	
Oat	86.7[a]	80.9[a]
Rye	74.7[ab]	83.8[a]
Wheat	64.8[b]	85.7[a]
LSD (.05)	----------12.7----------	

[a,b] Means without common superscripts within a column differ ($P < .05$).

[1] Rows evaluated for coverage 56 days after seeding (November 20, 1997) by tabulating blank spaces (in tenths of a foot). Coverage calculated as: coverage (%) = 100 - ([blank spaces / 20 ft] x 100).

Table 3. Growth stage (Stauss, 1994; see Table 1), plant height, and forage yield for three fall-seeded cereal grains harvested on five dates in spring 1998 at Batesville.

Harvest date	Growth stage	Plant height	Yield
		in	lb acre^{-1}
Oat			
March 4	27[d]	5.3[d]	666[c]
March 24	26[d]	6.6[d]	720[c]
April 15	43[c]	16.5[c]	1670[b]
May 4	59[b]	26.4[b]	2258[b]
May 26	78[a]	33.8[a]	4053[a]
LSD (.05)	1.1	1.9	677
Rye			
March 4	31[e]	8.0[d]	461[d]
March 24	32[d]	12.3[c]	748[d]
April 15	59[c]	40.4[b]	2527[c]
May 4	70[b]	57.4[a]	3627[b]
May 26	83[a]	56.2[a]	4981[a]
LSD (.05)	0.4	2.4	1146
Wheat			
March 4	30[d]	8.1[d]	433[d]
March 24	31[d]	9.5[c]	410[d]
April 15	51[c]	20.8[b]	1153[c]
May 4	70[b]	26.7[a]	1709[b]
May 26	84[a]	26.7[a]	2415[a]
LSD (.05)	1.1	1.3	553

[a,b,c,d,e] Means without common superscripts within both a column and a single forage species differ ($P < .05$).

Table 4. Linear regressions of forage dry matter yield on forage height for three fall sod-seeded cereal grains harvested on five dates in Batesville during the spring of 1998.

	Regression statistics					
Forage	n	Slope[1]	SE_{slope}	Intercept[2]	$SE_{intercept}$	r^2
Oat	80	119	10	-229	201	0.666
Wheat	80	101	11	-640	215	0.538
Rye	80	88	9	-586	366	0.553

[1] Units for slope are lb/acre/in; slopes did not differ ($P > .05$) across species.
[2] Units for intercept are lb/acre; intercepts differed across species ($P < .05$).

Forage Quality Characteristics and Dry Matter Digestion Kinetics of Sod-Seeded Cereal Grains in Northern Arkansas

W.K. Coblentz[1], K.P. Coffey[1], J.E. Turner[1], D.A. Scarbrough[1], J.S. Weyers[1], K.F Harrison[2], L.B. Daniels[1], C.F. Rosenkrans, Jr.[1], D.W. Kellogg[1], and D.S. Hubbell, III[2]

Story in Brief

Wheat, oat, and rye were overseeded into a dormant bermudagrass sod and harvested at 3-week intervals throughout the spring. Plant growth stage was documented for each forage on each harvest date, and harvested forages were evaluated for forage quality characteristics. Digestion kinetics of dry matter (DM) were also evaluated by the in situ method for these forages. Forage quality was exceptionally high for these forages through the early stages of stem elongation; the associated degradation kinetics indicated that potential extents of degradation were high and rates of degradation were rapid. Forage quality declined and parameters associated with degradation kinetics were less desirable as plants entered the reproductive stages of growth. This process was more rapid for rye than the other cereal grains. A single harvest for hay or silage at boot stage or soon thereafter may represent the best compromise between forage yield and quality.

Introduction

Cereal grains have been drilled routinely into dormant warm-season grass sods in an attempt to provide fall, winter, and spring grazing for a variety of livestock enterprises. This practice works well in southern Arkansas because the climate is favorable for some continued growth of cereal grains throughout the late fall and winter and other options for cool-season perennial forages are limited. In northern Arkansas, growth is delayed further into the spring, and adequate forage availability to support grazing ruminants can not be counted on until early or mid-March. While grazing is still the most common method of delivering these forages to livestock, specific "niche" uses can be observed throughout the region; these include harvesting the crop on a whole-plant basis as hay, balage, or chopped silage. This approach also has the added advantage of removing the entire canopy at one time, thereby limiting the suppression of the subsequent crop of bermudagrass. The objectives of this study were to evaluate oat, wheat, and rye harvested on six dates between early March and early June for quality and DM digestion characteristics. An additional objective was to evaluate these forages for growth stage on each harvest date, and relate DM digestion characteristics to growth stage by various nonlinear regression models.

Experimental Procedures

Establishment. This study was conducted at the Batesville Livestock and Forestry Branch Station located near Batesville. The base sod at this site was a well-established stand of 'Tifton 44' bermudagrass that was harvested as hay in mid-August. Regrowth following haying was limited because of droughty weather conditions; no further removal of existing vegetation was attempted prior to establishing the study. Existing vegetation at the experimental site was estimated by clipping all vegetation (alive and dead) within four 1/4-m^2 frames selected from random locations throughout the site. The mean residual plant DM was calculated to be 213 lb/acre. Prior to establishing the plots, the site was fertilized to soil test recommendations for fall-seeded cereal grains. Cereal grain varieties selected for this study included 'Jay Pee' wheat, 'Elbon' rye, and 'Ozark' oats. Plots were drilled in 10-in rows with a 80-in wide Tye Pasture Pleaser Drill (The Tye Company, Lockney, Texas) on 24 September 1997 at seeding rates of 90, 90, and 96 lb of pure live seed per acre for wheat, rye, and oat, respectively. Individual plots (10 by 30 ft) were drilled with a single drill pass and arranged in a randomized complete block design with four replications. All plots were fertilized with an additional 50 lb of nitrogen per acre on 14 February 1998.

Sampling and Quality Analysis. Each forage was harvested at a 1-in stubble height with hand shears on six dates (4 March, 24 March, 15 April, 4 May, 26 May, and 5 June). In association with each harvest, three plants in each plot were evaluated for growth stage by the method of Stauss (1994; Table 1). Forages were dried under forced air at 122°F and subsequently ground through a 1-mm screen in a Wiley Mill (Arthur H. Thomas, Philadelphia, Pennsylvania). Samples were analyzed for neutral detergent fiber (NDF),

[1]Department of Animal Science, Fayetteville.
[2]Livestock and Forestry Branch Experiment Station, Batesville.

acid detergent fiber (ADF), and crude protein (CP). Total digestible nutrients (TDN) were calculated from prediction equations for cereal grain forages used by the Cooperative Extension Service (TDN = 73.5 + [0.62 x CP] - [0.71 x ADF]). Crude protein, NDF, and ADF were evaluated by standard analytical procedures. Forage quality indices were analyzed as a randomized complete block design with repeated measures. Because of the unique effects that grain fill has on forage quality indices, heads were removed from each plant and weighed on the 26 May and 5 June harvest dates to determine the percentage of total plant DM partitioned within the filling grain head.

In Situ Analysis of DM Disappearance. Four 999-lb ruminally cannulated crossbred steers were used to determine in situ degradation characteristics. Surgical procedures and anesthesia for cannulations and care of the steers were approved by the University of Arkansas Institutional Animal Care and Use Committee. Steers were housed in individual 11 by 16-ft pens and offered a total mixed ration at 1.75% of BW throughout the trial. The ration contained (as-is basis) 49.3% shredded alfalfa hay (21.0% CP, 54.4% NDF, and 33.0% ADF), 45.9% cracked corn, 3.0% soybean meal, 1.0% molasses, 0.36% dicalcium phosphate, 0.46% salt, plus a vitamin premix. Water was provided for each steer for ad libitum intake. Steers were fed twice daily in equal portions (0700 and 1600 h) and were adapted to the basal diet for 10 d prior to initiating the trial.

Standard in situ procedures were used in the trial. Dacron bags (10 x 20 cm; 53 ± 10-ìm pore size; Ankom Co., Fairport, New York) were filled with 5-g samples of dried ground forage that had previously been ground through a 2-mm screen in a Wiley mill. All bags for each time period were placed in a 36- x 50-cm mesh bag and soaked in tepid (102°F) water for 20 minutes to remove water-soluble components and reduce lag time associated with wetting. All bags, except at 0 hours, were inserted into the ventral rumen simultaneously just prior to feeding (0800 hours) and incubated for 3, 6, 9, 12, 24, 36, 48, 72, or 96 hours.

After the appropriate interval, mesh bags were removed from the steers and the contents were emptied into a top-loading washing machine and rinsed; dacron bags from all five steers were rinsed simultaneously (90 per period). Bags were subjected to six cold-water rinse cycles with 1 minute of agitation and a 2-min spin per rinse. Zero-hour bags were rinsed immediately after soaking in tepid water. After rinsing, dacron bags containing forage residues were dried to a constant weight at 122°C. After bags were dried, they were allowed to equilibrate with the atmosphere before subsequent analysis for residual DM.

Dry matter was partitioned into three fractions based on relative susceptibility to ruminal degradation. The A fraction was defined as the immediately soluble portion; the B fraction was comprised of DM degraded at a measurable rate; and the C fraction was considered undegradable in the rumen. Fraction A was determined directly by measuring the DM washed from zero-hour bags in the washing machine. Fraction C was calculated as the portion of DM remaining in dacron bags that had been incubated for 72 hours; conversely, the maximum extent of degradation was calculated as the portion of DM that disappeared from dacron bags in a 72-hour ruminal incubation. Fraction B was determined by difference (B = 100 - A - C). Data were fitted to the nonlinear regression model described by Mertens and Loften (1980). Lag times and degradation rate constants were determined directly from the model. Data for each forage species were analyzed as a randomized complete block design with harvest dates as treatments and steers as the blocking term. An independent analysis of variance was conducted for each cereal forage. Forages harvested on March 4 were not evaluated *in situ* because of limited sample availability. *In situ* digestion parameters were related to plant growth stage by various nonlinear regression techniques.

Results and Discussion

Forage Quality. As expected, forage quality (Table 2) for all cereal grains declined generally with calendar date at harvest and with growth stage. Forage quality indices throughout March were excellent for all species; CP for the three species ranged from 19.4 to 25.4% over the March 4 and 24 March harvest dates. During this time period, NDF ranged from 40.7 to 42.9%, ADF ranged from 19.6 to 20.4%, and TDN was greater than 72%. The quality characteristics for rye declined more rapidly than the other cereal grains. By 15 April, when the inflorescence was approaching full emergence, the CP concentration had fallen to 8.6%, representing a decline of 11.9 percentage units in a 3-week time interval. Concentrations of NDF and ADF increased dramatically during this same harvest interval (by 25.8 and 14.9 percentage units, respectively). Estimates of TDN also declined from 75.3 to 54.1% in response to the elevated levels of fiber components, thereby indicating a significant reduction in the energy content of the forage. Forage quality for wheat and oat declined similarly, but the extent of decline was less pronounced. This was probably related to the slower plant growth and development characteristics of these species. By 15 April, the inflorescence of wheat plants was just beginning to emerge; however, oat plants were even less mature, and just beginning to exhibit swelling in the flag leaf sheath. Generally, forage quality continued to decline for all species through the harvest date on 4 May. Following this harvest date, the ADF concentration in wheat declined noticeably, but not significantly ($P > .05$), probably in association with grain development (Table 3). In association with this change, the TDN concentration increased by 3.4 percentage units,but this estimate was not different ($P > .05$) from estimates made on 4 May or 5 June. A similar, nonsignificant ($P > .05$) reduction in ADF and associated increase in TDN was observed between the harvest dates on 26 May and 5 June for rye. Whole-plant estimates of CP for all species were < 8.0% by the 4 May harvest date.

In Situ DM Disappearance. The extent of DM disappearance (Table 4) was extremely high (≥ 92%) for all cereal grains on March 24. For all cereal grains, the extent of

disappearance declined ($P < 0.05$) with harvest date and plant growth stage. For both oat and wheat, the extent remained > 70%, even on the June 5 harvest date. In contrast, the extent of DM disappearance for rye fell below 70% by May 4. Rates of DM disappearance were rapid (range = .086 to .111/hour) for all forages on March 24. These rates declined ($P < 0.05$) with harvest date; however, rates for rye slowed dramatically (.043/hour) by April 15 and did not change ($P > .05$) thereafter. The decline in degradation rates with advancing harvest dates was slowest for oat, reflecting the slower growth and development characteristics of this species. However, rates of disappearance for all forages were generally slow ($\leq .05$/hour) for the May 4, May 26, and June 5 harvest dates. The partitioning of DM into fractions A, B, and C was strongly affected by both the negative effects of increasing calendar date and plant maturity, as well as grain development and fill. Fraction A, which represents the portion of plant DM that is immediately soluble in the rumen, decreased for all cereal grains between March 24 and May 4. Between May 4 and June 5, fraction A changed little in wheat, but increased sharply in both oat and rye. These observations are likely related to grain fill. Dry matter that is unavailable in the rumen (fraction C) increased ($P < 0.05$) with harvest date in likely association with increased lignification of the straw. Fraction B declined ($P < 0.05$) with harvest date as lignification of the straw increased fraction C in all forages and grain fill increased fraction A in oat and rye.

Relating Digestion Kinetics and Growth Stage. The relationsihps between kinetic parameters of DM disappearance and plant growth stage are illustrated in Figs. 1 and 2. The relationship between the extent of DM degradation and growth stage was best defined by a third-order polynomial model (Fig. 1), and exhibited good r^2 statistics ($r^2 \geq 0.989$) for all cereal grains. The potential extent of degradation for cereal rye declined rapidly with increased growth stage; the corresponding patterns of decline for wheat and oat were much slower. The relationship between degradation rate and growth stage was best explained with a second-order polynomial model, which exhibited good r^2 statistics ($r^2 > 0.959$) for all three cereal grains.

Implications

Cereal grain forages grown in northern Arkansas clearly possess outstanding forage quality characteristics through the vegetative and early stem elongation stages of growth. As the reproductive process begins, substantial increases in concentrations of forage fiber components are accompanied by decreases in CP and TDN; these characteristics occur more rapidly in rye. Dry matter degradation rates for all cereal grains were rapid (approximately 10%/hour) for immature plants, but slowed substantially by the time grain development and fill began. In grazing situations, every effort should be made to maximize use of vegetative growth. These results suggest that single harvests for hay or silage should be made at boot stage or soon thereafter; this appears to offer the best compromise between yield and quality.

Literature Cited

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Table 1. BBCH (European) uniform decimal code for describing morphological development of cereal crops (Stauss, 1994).

Code	Morphological descriptor
Principal growth stage 1: leaf development	
10	first leaf through coleoptile
11 to 18	leaves 1 to 8 unfolded
19	9 or more leaves unfolded
Principal growth stage 2: tillering	
20	no tillers
21	beginning of tillering, first tiller detectable
22 to 28	2 to 8 tillers detectable
29	9 or more tillers detectable
Principal growth stage 3: stem elongation	
30	beginning of stem elongation
31	first node at least 1 cm above tillering node
32 to 38	nodes 2 to 8 detectable
Principal growth stage 4: booting	
41	early boot stage, flag leaf sheath extended
43	midboot stage, flag leaf sheath just visibly swollen
45	late boot stage, flag leaf sheath swollen
47	flag leaf sheath opening
49	first awns visible
Principal growth stage 5: heading	
51	tip of inflorescence emerged from sheath, first spikelet just visible
53	30% of inflorescence emerged
55	50% of inflorescence emerged
57	70% of inflorescence emerged
59	inflorescence fully emerged
Principal growth stage 6: flowering, anthesis	
61	beginning of flowering, first anthers visible
65	full flowering, 50% of anthers mature
69	end of flowering, all spikelets have completed flowering but some dehydrated anthers may remain
Principal growth stage 7: development of fruit	
71	watery ripe, first grains have reached half their final size
73	early milk
75	medium milk, grain content milky, grains final size, but still green
77	late milk
Principal growth stage 8: ripening	
83	early dough
85	soft dough, grain content soft but dry, fingernail impression not held
87	hard dough, grain content solid, fingernail impression hard
89	fully ripe, grain hard, difficult to divide with a thumbnail
Principal growth stage 9	
92	over-ripe, grain very hard, cannot be dented by thumbnail
93	grains loosening in day time
97	plant dead and collapsing
99	harvested product

Table 2. Quality characteristics of three overseeded cereal grains as affected by harvest date and growth stage.

Forage/ harvest date	Growth stage[1]	CP[2]	NDF	ADF	TDN
	---------- (% of DM) ----------				
Oat					
March 4	29[e]	21.6[a]	42.8[c]	19.9[b]	72.8[a]
March 24	26[f]	19.4[b]	40.7[c]	19.7[b]	71.6[a]
April 15	42[d]	11.8[c]	50.8[b]	24.9[b]	63.1[b]
May 4	59[c]	7.8[d]	62.2[a]	34.3[a]	54.0[c]
May 26	78[b]	5.6[e]	62.8[a]	34.9[a]	52.2[c]
June 5	88[a]	5.9[e]	62.7[a]	37.2[a]	50.7[c]
Wheat					
March 4	31[e]	21.3[a]	42.2[c]	20.4[cd]	72.2[a]
March 24	31[e]	20.4[a]	41.4[c]	19.9[d]	72.1[a]
April 15	50[d]	10.7[b]	50.9[b]	26.2[bc]	61.5[b]
May 4	70[c]	6.7[c]	56.5[ab]	36.3[a]	51.9[c]
May 26	84[b]	6.2[c]	59.9[a]	31.1[ab]	55.3[c]
June 5	89[a]	6.4[c]	61.3[a]	37.1[a]	51.2[c]
Rye					
March 4	31[e]	25.4[a]	42.9[c]	19.6[c]	75.3[a]
March 24	32[e]	20.5[b]	41.8[c]	19.9[c]	72.1[a]
April 15	58[d]	8.6[c]	67.6[ab]	34.8[b]	54.1[b]
May 4	70[c]	4.5[d]	74.0[a]	42.9[a]	45.8[c]
May 26	83[b]	4.1[d]	65.5[b]	44.3[a]	44.6[c]
June 5	89[a]	5.5[d]	68.0[ab]	41.2[a]	47.7[c]
SEM[3]	0.7	0.63	2.58	2.14	2.20

[a,b,c,d,e,f] Means in a column within a forage species with different superscripts differ ($P \leq .05$).

[1] Growth stage determined by the scale described by Stauss (1994).

[2] Abbreviations: CP = crude protein, NDF = neutral detergent fiber, ADF = acid detergent fiber, TDN = total digestible nutrients, and DM = dry matter.

[3] Standard error of forage by harvest date interaction means (n = 4).

Table 3. Percentages of total plant dry matter found in the heads of cereal grains on two harvest dates.

Forage species	Harvest date	
	May 26	June 5
	----------% of DM ----------	
Oat	53.6[a]	55.1[a]
Rye	36.1[b]	41.4[b]
Wheat	57.9[a]	60.1[a]
SEM[1]	1.31	1.69

[a,b] Means without common superscripts within a column differ ($P < .05$).

[1] Standard error of the mean.

Table 4. *In situ* DM degradation characteristics for three cereal grains. Characteristics for the harvest date on March 4 were not evaluated.

Forage/ harvest date	A[1,2]	B	C	72-hour extent[2,3]	Lag time	k	Effective degradability[4]
	---------- (% of DM) ----------				(h)	(h^{-1})	% of DM
Oat							
March 24	48.3	43.9^{c}	7.8^{c}	92.2^{a}	2.3^{b}	.086^{a}	77.8
April 15	42.8	48.8^{b}	8.4^{c}	91.6^{a}	1.9^{b}	.063^{b}	71.9^{b}
May 4	31.0	51.5^{a}	17.4^{b}	82.6^{b}	2.3^{b}	.046^{c}	57.8^{c}
May 26	42.3	33.1^{c}	24.6^{a}	85.4^{c}	5.0^{a}	.036^{c}	57.6^{c}
June 5	39.4	34.4^{c}	26.2^{a}	73.8^{c}	4.6^{a}	.035^{c}	55.0^{d}
SEM[5]	---	0.54	0.54	0.54	0.61	.0038	0.60
Wheat							
March 24[6]	45.2	47.3^{a}	7.5^{d}	92.5^{a}	1.8^{b}	.111^{a}	78.5^{a}
April 15	41.4	46.6^{a}	12.0^{c}	88.0^{b}	1.6^{b}	.056^{b}	67.8^{b}
May 4	37.7	37.4^{b}	24.9^{b}	75.1^{c}	4.4^{a}	.048^{b}	57.5^{c}
May 26	36.3	35.3^{c}	28.4^{a}	71.6^{d}	0.0^{b}	.038^{b}	53.1^{d}
June 5	37.7	32.6^{d}	29.7^{a}	70.3^{d}	0.0^{b}	.040^{b}	53.6^{d}
SEM	---	0.57	0.57	0.57	0.54	.0091	0.99
Rye							
March 24[6]	45.2	49.7^{a}	5.1^{d}	94.9^{a}	0.9^{ab}	.099^{a}	80.0^{a}
April 15	28.9	49.9^{a}	21.2^{c}	78.8^{b}	2.5^{a}	.043^{b}	54.2^{b}
May 4	22.6	41.2^{b}	36.2^{b}	63.8^{c}	1.9^{a}	.034^{b}	41.1^{d}
May 26	25.1	36.9^{c}	38.0^{ab}	62.0^{cd}	0.0^{b}	.045^{b}	44.1^{c}
June 5	29.0	32.1^{d}	38.9^{a}	61.1^{d}	0.0^{b}	.034^{b}	43.4^{c}
SEM[3]	---	0.74	0.74	0.74	0.55	.0040	0.54

^{a,b,c,d} Means in a column within a forage species with different superscripts differ ($P \leq .05$).

[1] Abbreviations: A = Immediately soluble fraction, B = fraction degradable at a measureable rate, C = undegraded fraction, and k = degradation rate.

[2] Fraction A determined directly as the portion of total dry matter removed from dacron bags by rinsing.

[3] Extent of degradation after 72-hour incubation in the rumen.

[4] Calculated as A + B (k/k + passage rate), where mean passage rate for four animals was .042 h^{-1}.

[5] Standard error of harvest date means (n=4). Each cereal grain forage was analyzed by separate analysis of variance.

[6] Evaluated in three animals.

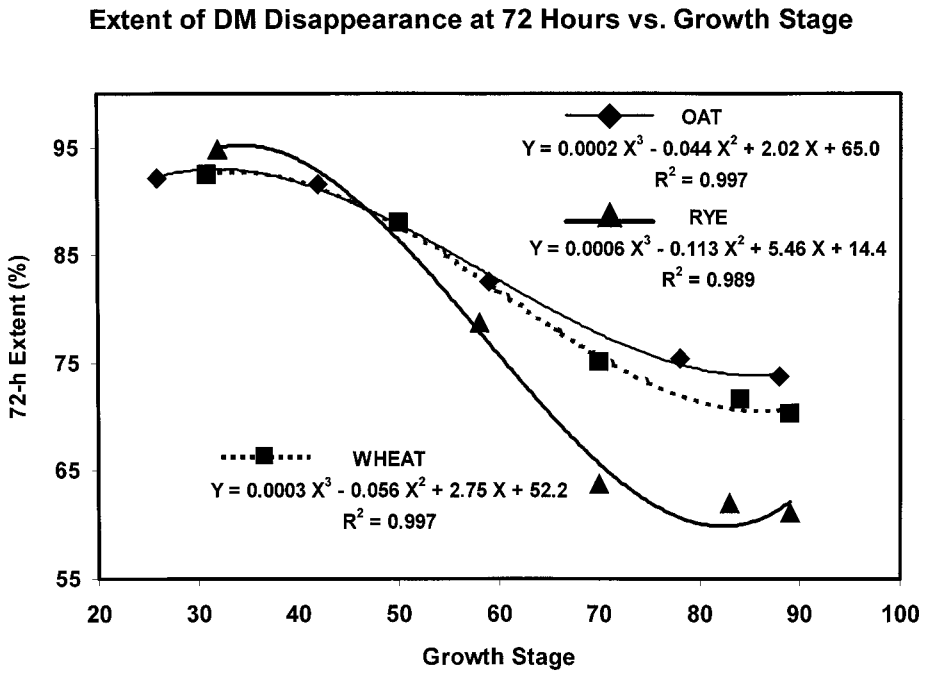

Fig. 1. Third-order polynomial regressions of the extent of ruminal disappearance of DM on growth stage for wheat, oat, and rye harvested on five dates during the spring of 1998 at Batesville, AR.

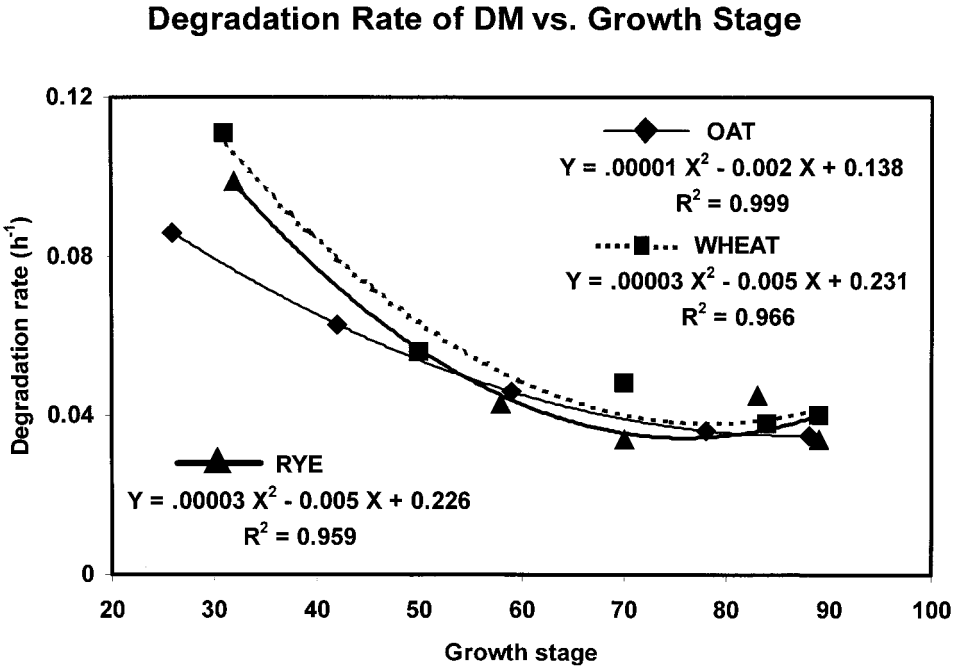

Fig. 2. Second-order polynomial regressions of degradation rate for ruminal disappearance of DM on growth stage for wheat, oat, and rye harvested on five dates during the spring of 1998 at Batesville, AR.

A Field Trial on the Effectiveness of Popular Anthelmintics in Arkansas Horses

Shelly Ryan[1], Ron McNew[2], T. A. Yazwinski[1], Chris Tucker[1], Sharon Copeland[1], and Paul Turchi[3]

Story in Brief

In a field trial conducted from June, 1997 to June, 1998, a total of 218 horses from six different farms in northwest Arkansas were used in the performance of an egg count reduction test to evaluate the effectiveness of four commonly used anthelmintics (dewormers). At each farm, horses were randomly allocated to one of four treatment groups (ivermectin, oxibendazole, fenbendazole, and pyrantel), and treated according to manufacturers' instructions. Feces, obtained from each animal on the day of treatment (day 0) and again 14 days later (day 14), were used for the determination of nematode egg per gram (EPG) counts. Anthelmintic effectiveness was in turn determined by calculating day 14 reductions from day 0 levels. Several parasite egg types were quantified, but the one of most practical importance was the Strongyle; an egg which indicates the abundance and activity of the vast majority of parasites in the horse's intestinal tract. Average per farm percentage reductions of Strongyle EPG counts were 63.5 (fenbendazole), 89.2 (oxibendazole), 95.6 (pyrantel) and 99.4 (ivermectin). Overall characterization of the egg count reductions as exhibited by the anthelmintics are; poor (fenbendazole), borderline (oxibendazole), good (pyrantel) and excellent (ivermectin).

Introduction

The horse serves as host to a vast array of metazoan parasites which, for the most part, inhabit its intestinal tract. In a recent paper (Fredrickson, 1999), these parasites are listed along with their distinguishing characteristics. Parasite induced detriment to the horse varies with a number of factors, but the three most important factors are the state of horse resistance, parasite species and parasite abundance. Since horses will always harbor parasites (no anthelmintics are 100% effective coupled with the fact that every trip to the pasture translates into more parasites in the horse), the objectives of an anthelmintic program should not be to "cure" the horse but rather to reduce the parasite population in the horse to non-detrimental levels plus limit the extent of parasite challenge in the horse's environment. In order to attain these objectives, it is important that anthelmintic effectiveness be assessed on both a farm and regional basis (Reinemeyer et al., 1990). The study reported herein stands as the first and only investigation undertaken in Arkansas that was designed to evaluate commonly used anthelmintics in horses. Data from this investigation should prove highly useful to Arkansas horse owners as they decide which anthelmintics to use in order to provide effective parasite control on their farms.

Experimental Procedures

Animals - A total of 218 horses from six cooperating farms located in northwest Arkansas were used. Procedures were conducted at one farm at a time and the entire study lasted for one year (June 1997 to June 1998). Both male and female horses were used. Body weights (measured by a commercial horse and pony height-weight tape) ranged from 200 (miniature horse) to 1300 lb on the day of treatment. Animal age ranged from 6 months to 25 years and Quarterhorse was the predominate breed. Animal numbers per farm ranged from 15 to 61 (average of 36). Numbers of horses as female, male, < 1 year of age and > 1 year of age were 141, 77, 60, and 158, respectively.

Treatments - At each site, horses were randomly allocated to one of four treatment groups and treated accordingly. The treatments (molecule and formulation names), manufacturers and dosage rates were; ivermectin (Eqvalan®, Merial, 0.2 mg/kg BW), fenbendazole (Safe-Guard®, Hoechst Roussel Vet, 5.0 mg/kg BW), pyrantel pamoate (Strongid Paste®, Pfizer, 6.6 mg/kg BW) and oxibendazole (Anthelcide EQ®, Pfizer, 10.0 mg/kg BW). All anthelmintics were administered in paste formulation and at manufacturers' recommended dosages. Care was taken during treatment to ensure that all administered product was indeed consumed by the horses.

[1] Department of Animal Science, University of Arkansas
[2] Agricultural Statistics Lab, University of Arkansas
[3] Northwest Equine Services, Fayetteville, Arkansas

Parasitology - Pretreatment (day 0) and post-treatment (day 14) fecal samples were obtained from each study animal. For each fecal sample, the number of nematode eggs per gram of feces (EPG) was determined according to standard procedure (Parfitt, 1955). For fecal samples with an EPG of ≥ 20, coproculture and infective larvae differentiations were performed according to established techniques and specifications (Ministry of Agriculture, Fisheries and Food [UK], Technical Bulletin No. 18).

Statistics - Initially, EPG counts were transformed to the log10 $(x + 1)$ to reduce variance inherent to these data. Day 0 and day 14 geometric means were then assessed for significant differences using a t-test. In order to determine significant differences in EPG reductions (site to site differences per treatment and treatment to treatment differences per site), day 0 versus day 14 EPG percentage reductions were calculated for each animal (non-transformed data), and the treatment group means calculated and analyzed for significant differences using a multiple t-test. All data were analyzed using a current statistical analysis program (SAS, 1988).

Results

Day 0 fecal samples from all study animals contained Strongyle eggs, indicating a 100% prevalence for patent infections. Incidence of cestode, Parascaris equorum and Strongyloides westeri eggs in day 0 fecal samples was 24, 7 and 6%, respectively. Pre-treatment (day 0) Strongyle EPG geometric means as a property of site, horse sex and horse age are presented in Table 1. Differences were significant between sites, but horse gender and age did not significantly influence the egg counts.

Day 0 and day 14 Strongyle EPG geometric means are given in Table 2 for all treatment groups by site. Day 0 EPG counts did not vary significantly between treatment groups on any of the farms, indicating the adequacy of the randomization procedure. For all sites, ivermectin and pyrantel treatment resulted in post-treatment egg counts significantly reduced from those determined for day of treatment ($P < .05$). Treatment of horses with oxibendazole yielded significant egg count reductions on five of the six farms, whereas treatment with fenbendazole provided significant egg count changes on only three of the six farms. On one site (farm S), EPG geometric means for horses of the fenbendazole treatment group actually increased by 48% from day 0 to day 14.

Mean percentage reductions in Strongyle egg counts by treatment group specific to farm are presented in Table 3. Mean percent reductions by farm for ivermectin, pyrantel, oxibendazole and fenbendazole treatment groups ranged from 98.8 to 99.8, 88.7 to 99.0, 68.6, to 99.5 and 10.8 to 92.5, respectively. Significant differences in anthelmintic effectiveness were noted among sites for each product used, as well as among anthelmintics at each study site ($P < .05$).

Coproculture and infective larvae differentiations were conducted on 169 day 0 and 74 day 14 fecal samples. All Strongyle larvae were of the cyathostome (small Strongyle) classification. A small number of T. axei larvae were found in approximately 25% of the samples.

Discussion

As previously stated, the objectives of anthelmintic treatment are (1) to reduce the parasite burden in the treated animal to a non-detrimental level and (2) to limit the extent of parasite contamination and challenge in the animal's environment. In regard to the first objective, data accumulated in the current study (i.e., EPG counts) are at best indirect assessments of worm removal since egg laying activity is monitored as opposed to worm numbers. Limitations not withstanding, a threshold of 80% EPG reduction has been forwarded as the minimal activity which can be considered indicative of effective parasite removal (Ehlinger and Kristula, 1992). Using the above criteria, only ivermectin and pyrantel provided effective therapy on every farm. Of the six study farms, oxibendazole proved inadequate (< 80% mean EPG reduction) on one farm and fenbendazole was less than effective on five of the six farms. A more critical interpretation of EPG reductions and coincident anthelmintic effectiveness establishes a 90% EPG reduction as the threshold between efficacious and "undesirable" (Coles et al., 1988). According to this latter guideline, only ivermectin provided effective worm control at all study sites.

In regard to lessening parasite challenge in the horse's environment (objective 2 above), EPG count is directly related since fecal eggs, provided optimal conditions of moisture and temperature, result in infective pasture larvae in one week. Significant reductions in eventual parasite challenge was the consistent result of treatment with ivermectin and pyrantel, with post-treatment EPG counts significantly reduced from day 0 levels for both products on all farms. Oxibendazole can be seen as significantly reducing contamination/challenge on five of the six farms, whereas fenbendazole provided significant reductions on only three of the six farms.

Oxibendazole and fenbendazole are classified as benzimidazoles. Results from the current study clearly indicate that benzimidazole resistance is well established in the Strongyle populations in Arkansas horses. This phenomenon was first detected soon after drugs of this compound class were cleared for use in horses (Drudge et al., 1979). Benzimidazole resistance is now common to all horse production areas. The abundance of these Strongyles is of such proportion that current guidelines for anthelmintic evaluation in horses establish criteria for their documentation and effective therapy (Coles et al., 1992).

The current report is on an investigation into the activity of four anthelmintics commonly used in Arkansas as of 1997. Since that time, another parasiticide has become available for use in horses which is of unique classification albeit closely related to ivermectin. This new chemical is moxidectin, and it is marketed under the trademark of Quest® (Fort Dodge Animal Health). Data from initial studies indicate that moxidectin is similar to ivermectin in most mea-

surements of efficacy, but that it is superior to ivermectin in activity against encysted (reservoir) Strongyles (Xiao et al., 1994). This greater spectrum of activity translates into greater periods of post-treatment egg count suppression than have been seen here-to-fore with any other product. Research is now in progress at the University of Arkansas to further document the effectiveness of milbemycin, as well as provide additional data on the activity of other equine parasiticides.

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Table 1. Levels of pretreatment, Strongyle EPG counts

Source	N	EPG		
		Geometric Mean	Minimum	Maximum
Site C	30	129.7[c]	6	1014
Site H	61	164.4[c]	2	2538
Site J	17	124.5[bc]	9	666
Site P	46	438.5[a]	2	6502
Site S	15	427.6[a]	78	3948
Site T	49	479.7[ab]	1	6226
Female horses	141	275.4	-	-
Male horses	77	235.0	-	-
Horses < 1 yr of age	60	290.4	-	-
Horses > 1 yr of age	158	249.5	-	-

[a,b,c] Means in the same category with unlike superscripts are significantly different (P < .05).

Table 2. Pretreatment and post-treatment Strongyle EPG geometric means by treatment group and site.

	Strongyle EPG geometric mean:							
	Pretreatment (day 0)				Post-treatment (day 14)			
Site	Oxibendazole	Ivermectin	Fenbendazole	Pyrantel	Oxibendazole	Ivermectin	Fenbendazole	Pyrantel
C	128.8[a]	102.3[a]	181.9	85.1[a]	15.1[b]	1.4[b]	81.3	13.8[b]
H	141.3[a]	166.0[a]	199.5[a]	138.0[a]	6.5[b]	1.2[b]	56.2[b]	7.2[b]
J	162.2[a]	120.2[a]	89.1	141.3[a]	36.3[b]	3.7[b]	24.5	12.0[b]
P	489.8[a]	631.0[a]	371.5[a]	407.4[a]	56.2[b]	1.3[b]	151.4[b]	11.7[b]
S	575.4	466.7[a]	562.3	251.2[a]	389.0	6.2[b]	831.8	22.9[b]
T	645.7[a]	257.0[a]	446.7[a]	660.7[a]	3.2[b]	1.3[b]	33.1[b]	6.9[b]

[a,b] Day 0 and day 14 EPG means of the same site and treatment group designation with unlike superscripts are significantly different ($P < .05$).

Table 3. Mean percent reductions of Strongyle EPG counts (day 0 vs. day 14) by treatment group for each site.

	Treatment (dose rate)			
Site	Oxibendazole (10.0 mg/kg)	Ivermectin (0.2 mg/kg)	Fenbendazole (5.0 mg/kg)	Pyrantel (6.6 mg/kg)
C	89.5[2] [bc]	98.8[1] [b]	58.4[2] [b]	88.7[2] [c]
H	96.6[2] [b]	99.3[1] [b]	78.9[3] [a b]	95.4[2] [bc]
J	89.5[2,3] [bc]	99.2[1] [ab]	75.8[3] [ab]	97.2[1,2] [abc]
P	91.4[3] [bc]	99.8[1] [a]	64.6[4] [b]	97.3[2] [ab]
S	68.6[2,3] [c]	99.7[1] [ab]	10.8[3] [b]	95.8[2] [abc]
T	99.5[1] [a]	99.6[1] [ab]	92.5[2] [a]	99.0[1] [a]

[1, 2, 3, 4] Means in the same row (within site) with unlike superscripts are significantly different (P < .05).
[a, b, c] Means in the same column (treatment group) with unlike superscripts are significantly different (P < .05).

1998 Dairy Herd Improvement Herds in Arkansas

Jodie A. Pennington[1]

Story in Brief

During 1998, 115 of the 488 dairy cattle herds in Arkansas were enrolled in the Dairy Herd Improvement (DHI) program. Sixty-six herds completed at least nine DHI tests with102 cows/herd averaging 15,176 lb milk, 539 lb fat, and 493 lb protein and 176 days in milk. Raw somatic cell count averaged 498,790. The value of milk sold per cow was $2,624; income over feed costs was $1,734.

Feed cost per CWT of milk was $6.37, or 37% of the average blend price for milk of $17.12. The 52 herds that were on official, supervised records averaged 99 cows/herd, 15,319 lb of milk/cow, and income over feed costs of $1,840. For the 14 herds using private, unsupervised DHI records, milk/cow averaged 14,665 lb with 110 cows in the herd and $1,278 income over feed costs. The Arkansas average for milk/cow is 13,041 lb/year. Herds not on DHI records average about 12,000 lb/year compared to the 15,176 lb for herds on DHI. This difference, approximately 3,000 lb/cow/year, affects income per cow by over $500/cow or approximately $50,000/year. The quartile data of milk production for the Holsteins with DHI records also reinforce that income over feed costs increases as milk production increases. Other records for health, reproduction, genetics, and inventory as well as production contribute to this difference in income/cow. Since less than 25% of the state's herds are enrolled in the DHI record-keeping program, opportunities exist for raising the level of milk production in the state by encouraging more producers to use DHI records.

Introduction

Successful dairy producers must have accurate and reliable records to make sound management decisions. The Dairy Herd Improvement (DHI) program provides a comprehensive herd analysis and management report that includes information concerning production, reproduction, genetics, herd health, animal and feed inventory, and finances. The data can be used to improve efficiency of milk production by (1) identifying least profitable cows for culling, (2) feeding for more efficient production, (3) selecting animals with the greatest genetic potential for production as replacements, and (4) utilizing summaries of the data to make precise management decisions that improve net income.

Typically, herds on DHI produce 3,500 to 4,500 lb more milk per year than herds not on DHI. This difference in production has a significant effect on net income for the dairies. Income over feed costs is associated with greater milk production per cow. The dairy herd summaries also allow a dairy producer to compare production, health, reproduction, and financial aspects of his/her dairy to other dairies, so that areas of management that need improvement can be detected.

Experimental Procedures

Dairy cattle herds on supervised test (n = 52) and unsupervised (n = 14) tests were used to report production and management data for DHI herds. Supervised herds used a certified field technician to collect data for the test milkings (or day) while unsupervised herds collected their own data. The test milking (or day) for each cow included weighing milk, taking a sample of milk to be analyzed for percentage of fat, protein and somatic cell count (SCC), plus recording of other management parameters as indicated in Table 1. Milksamples were analyzed at the Heart of America DHI Lab in Manhattan, Kansas. Records were processed at Dairy Records Management Services (DRMS), Raleigh, North Carolina.

Results and Discussion

Rolling herd averages for all supervised and unsupervised DHI herds are in Table 1. The weighted average milk/cow for the 66 herds was 15,176 lb/year. Supervised herds had a greater income over feed costs than unsupervised herds, primarily because of increased production per cow. This difference also resulted from greater milk price/cwt ($17.43 vs. $16.00).

Tables 2 and 3 show the DHI averages for the different breeds of cattle and quartile data of milk production for the Holstein breed. The breed data show the typical differences for the Holstein and Jersey breeds. Because of the high fat differential this year, Jersey milk averaged $2.12/cwt more than Holstein milk. Throughout the United States, Brown

[1]Animal Science Section, Cooperative Extension Service, Little Rock.

Swiss cows typically produce more than Guernseys. Much of the discrepancy here is probably due to the differences in percent in milk (79% for Brown Swiss vs. 92% for Guernseys).The quartile data for Holsteins illustrate the relationship of higher milk production to higher income over feed costs. However, the higher producing herds did tend to have decreased reproduction efficiency.

The 66 dairy cattle herds reported here is less than the 115 cattle herds that have been reported on DHI through other summaries. The primary reason for the difference in numbers is that herds reported here have at least nine test periods. There also were goat herds on the list that included any herd on DHI in 1999, including herds no longer on the DHI program. Still, less than 25% of the 488 herds in 1999 were involved in the DHI program. Herds on DHI averaged 15,176 lb milk/year compared to the Arkansas average of 13,041 lbmilk/year. Omitting DHI herds from the state average indicates that the non-DHI herds averaged about 12,000 lb milk/year. The difference of 3,000 lb milk/cow/year affects income by over $500/cow/year if the mailbox price of milk is $17.12. This difference in milk income is $50,000 per year in a 100-cow herd.

Implications

Participation in the DHI program affords dairy producers an opportunity to maintain milk production records on individual cows as well as records of other management practices. Herds using DHI records averaged 15,176 lb milk/cow/year compared to approximately 12,000 lb/cow for herds not on DHI test. The University of Arkansas Cooperative Extension Service needs to continue encouraging producers to enroll on the DHI Testing program.

Table 1. 1998 DHI Comparisons for Dairy Cow Herds in Arkansas by Type of Test.

Rolling herd averages	All herds (N = 66)	Supervised herds (N = 52)	Unsupervised herds (N = 14)
Milk (lb)	15,176	15,319	14,665
% Fat	3.8	3.8	3.7
Fat (lb)	539	549	498
% Protein	3.4	3.4	3.4
Protein (lb)	493	502	460
Days in milk	176	175	181
% in milk	83	84	78
Number cows/herd	102	99	111
Days dry	76	77	80
Standardized 150-day milk	54	55	49
Summit test day milk	60	60	59
1st Lactation (lb)	51	51	50
2nd Lactation (lb) index slightly	60	61	55
$\geq$ 3rd Lactation (lb)	67	67	63
Projected calving interval (mo)	14.1	14.2	13.6
Raw SCC (x 1,000)	499	472	597
Average age (mo)	53	51	59
% Heats observed	39	39	34
% Successful breedings	40	42	32
Services/conception - pregnant cows	1.7	1.9	0.9
Days to 1st service	87	97	50
Age 1st calving (mo)	27.9	27.9	28.1
Cow PTA $ - 1st Lactation	+117	+118	+109
Cow PTA $ - 2nd Lactation	+100	+96	+132
Cow PTA $ - 3rd Lactation	+68	+67	+80
Service proven sire PTA $	+187	+181	+221
% Cows leaving herd	34	35	28
% Cows 1st lactation	32	32	29
Feed cost/CWT milk	$6.37	$6.56	$5.56
Milk price/CWT	$17.12	$17.42	$16.00
Feed costs/year	$843	$880	$680
Income over feed ($ per cow)	$1,743	$1,840	$1,278

Table 2. 1998 DHI Comparisons for Dairy Cow Herds in Arkansas by Breed

	Breeds			
Rolling herd averages	Holstein (N = 52)	Jersey (N = 4)	Brown Swiss (N = 2)	Guernsey (N = 1)
Milk (lb)	16,012	12,094	13,555	14,288
Fat %	3.7	4.7	4.0	4.3
Fat (lb)	556	546	496	572
Protein %	3.3	3.9	3.7	3.9
Protein (lb)	512	453	484	427
Days in milk	170	160	190	270
% in milk	83	83	79	92
Number cows/herd	111	104	50	77
Days dry	75	73	88	85
Standardized 150-day milk	55	40	45	43
Summit test day milk	63	48	54	60
1st Lactation (lb)	54	40	47	52
2nd Lactation (lb) index slightly	63	47	58	61
≥ 3rd Lactation (lb)	70	53	61	67
Projected calving interval (mo)	14.1	14.0	14.8	16.7
Raw SCC (x 1,000)	511	322	369	427
Average age (mo)	53	51	49	52
% Heats observed	36	65	50	56
% Successful breedings	40	43	19	22
Services/conception - pregnant cows	1.7	2.2	1.1	2.5
Days to 1st service	86	85	46	104
Age 1st calving (mo)	28	26	30	27
Cow PTA $ - 1st Lactation	+124	+99	+136	+61
Cow PTA $ - 2nd Lactation	+108	+58	+120	+25
Cow PTA $ - 3rd Lactation	+180	+34	+52	+42
Service proven sire PTA $	+195	+183	+192	+127
% Cows leaving herd	35	16	26	24
% Cows 1st Lactation	31	30	41	42
Feed cost/CWT milk	$5.45	$5.59	$7.31	$9.18
Milk price/CWT	$16.85	$18.97	$18.41	$16.74
Feed costs/year	$865	$701	$1,051	$1,102
Income over feed ($ per cow)	$1,835	$1,712	$1,225	$1,215

Table 3. 1998 Arkansas DHI Comparisons - Holstein Herds

	Rolling Herd Averages - Arkansas Holstein Herds			
	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Milk (lb)	19,929	17,356	14,826	12,498
% Fat	3.4	3.5	3.5	3.5
Fat (lb)	674	598	520	433
% Protein	3.2	3.2	3.2	3.2
% Protein (lb)	639	557	481	402
Days in milk	191	183	198	183
% in milk	88.3	85.5	85.5	79.3
Days dry	69.8	68.2	80.6	86.8
Standardized 150-day milk	68.3	60.1	53.1	46.5
Peak milk - All	81.7	74.2	65.0	59.4
1st Lactation - lb	71.6	61.8	54.1	51.6
2nd Lactation - lb	83.2	74.3	65.4	60.9
$\geq$ 3rd Lactation - lb	91.2	81.1	69.1	61.6
Raw SCC x 1000	390	423	437	597
Days open	162	169	205	215
Freshening interval (mo)	14.5	14.8	15.9	16.3
Services/conception - all cows	3.2	2.3	2.7	2.4
Services/conception - pregnant cows	2.2	1.8	1.8	1.7
% Heat observed	36.5	33.3	27.9	31.0
AIPL PTA $ - cows	$61	$38	$19	$38
AIPL PTA $ - sires	$109	$81	$80	$69
Income over feed $ per cow	$1,918	$1,700	$1,588	$1,278

Comparison of Magnesium Sources on Muscle Color and Tenderness of Finishing Sheep[1]

Jason Apple, Butch Watson, Ken Coffey, and Beth Kegley[2]

Story in Brief

Twenty Rambouillet wether lambs were used to compare the effects of supplemental magnesium source on muscle color and tenderness of finishing sheep. Lambs were housed in individual pens and fed 1 of 4 high-concentrate finishing diets: 1) unsupplemented controls (C); 2) supplemented with 0.16% magnesium-oxide and 0.18% iron-sulfate (MgO+FeS); 3) supplemented with 0.9% unweathered Magnesium-Mica (UMM); or 4) supplemented with 1.0% weathered Magnesium-Mica (WMM). Sheep were fed for 95 days before slaughter. Following a 24-hour chill period, carcasses were fabricated into primal cuts, and CIE L*, a*, and b* values and reflectance spectral analysis were determined on the longissimus muscle (LM), triceps brachii (TB), semimembranosus (SM) and semitendinosus (ST) after a 45-min bloom period. Additionally, four 1-in thick LM chops were fabricated from the rack. One chop was analyzed for ether extractable lipid content, and three chops were cooked to an internal temperature of 160°F for Warner-Bratzler shear (WBS) force determinations. Magnesium source had no effect ($P > .10$) on objective color measurements of the LM, TB, SM, or ST. Longissimus muscle chops from lambs fed UMM had less ($P < .05$) intramuscular lipid and higher ($P < .05$) WBS force values than chops from C-lambs or lambs supplemented with MgO+FeS or WMM. Although magnesium-supplementation had no appreciable effects on muscle color, supplementing lamb finishing-diets with unweathered Magnesium-Mica may result in producing less palatable cooked lamb.

Introduction

Magnesium (Mg) is required in several biological reactions, including the protein synthesis and Mg-ATP complex in muscle. More recently, supplementing feedlot diets of finishing cattle with magnesium has been shown to increase marbling scores and the percentage of carcasses grading U. S. Choice, or higher (Coffey and Brazle, 1995; Coffey et al., 1995). In swine, supplementing finishing diets has been reported to reduce the incidence of pale, soft and exudative (PSE) carcasses and improve muscle color (Otten et al., 1992), and improve water-holding capacity in pork (Schaefer et al., 1993; D'Souza et al., 1998).

Magnesium oxide (MgO) is often the Mg supplement of choice because of its high Mg content (53.5%) and buffering capacity. Another Mg source is Magnesium-Mica, a silica-based product used primarily in the feed industry as a pellet binder. Magnesium-Mica contains approximately 8.9% Mg, has similar Mg bioavailability as MgO, and is less expensive; however, it also has a relatively high iron concentration (4%), which can have growth depressing effects in ruminants (Standish and Ammerman, 1971; Standish et al., 1971). Because of previous studies indicating a positive effect of supplemental Mg on meat quality and the scarcity of information comparing Mg sources on meat quality, the objective of this study was to compare the effects of supplemental Mg sources on muscle color and cooked meat tenderness.

Experimental Procedures

Twenty Rambouillet wether lambs (79.6 lbs.) were placed in individual pens and randomized to one of four ground corn-based diets for a 95-day feeding study. Treatment groups consisted of 1) a control (no supplemental source of magnesium or iron); 2) MgO at 0.16% and iron sulfate at 0.18% (MgO+FeS) of the diet; 3) unweathered Magnesium-Mica (UMM) at 0.9% of the diet; or 4) weathered Magnesium-Mica (WMM) at 1.0% of the diet. In the geographical formations from which Magnesium-Mica is mined, WMM lies close to the surface and has undergone weathering, whereas, UMM is located beneath WMM and has been protected from environmental exposure.

Lambs were slaughtered at the University of Arkansas Red-Meat Abattoir according to industry-accepted procedures. Carcasses were chilled at 34°F for 24 hours, then

[1] Appreciation is expressed to Micro-Lite, Inc. for providing Magnesium-Mica and partial financial assistance. Additionally, the authors would like to express their sincere appreciation to Dianna Watson, Eric Oxford, Jesse Davis, Jerry Stephenson, and Lilly Rakes for assistance in animal slaughter, carcass fabrication, and data collection, and to Dr. Zelpha Johnson for statistical consultation.

[2] All authors are associated with the Department of Animal Science, Fayetteville.

ribbed between the 12th and 13th ribs, and quality and yield grade data (USDA, 1987) were collected by university personnel. Carcasses were then fabricated into primal cuts according to the National Association of Meat Purveyors (NAMP, 1988) specifications. Commission Internationale de l'Eclairage L*, a*, and b* values (CIE, 1976) were measured with a Hunter MiniScan XE (Hunter Associates Laboratory, Inc., Reston, VA) on the longissimus muscle (LM) from the primal loin (NAMP #232), triceps brachii (TB) from the primal shoulder (NAMP #207), and the semimembranosus (SM) and semitendinosus (ST) from the primal leg (NAMP #233A) after a 45-min bloom period. A full reflectance spectral analysis was also take on each muscle and wavelength ratios were used to calculate relative deoxymyoglobin (474 nm:525 nm), oxymyoglobin (610 nm:525 nm), and metmyoglobin (572 nm:525 nm) concentrations.

The primal rack (NAMP #204) was fabricated into four 1-in thick LM chops. All bones and fat were removed from one chop, and the muscle portion was pulverized and used to measure the lipid content (USDA, 1987). Each of the remaining three chops were weighed, then cooked to an internal temperature of 160°F in a commercial convection oven (Blodgett Oven Co., Burlington, Vermont). Temperature was monitored with thermocouples, inserted into the geometric center of each chop, attached to a multichannel data recorder (VAS Engineering Inc., San Diego, California). Chops were reweighed after cooking, and the difference between the precooked and cooked chop weight was divided by the precooked weight to calculate cooking loss percentages. Chops were allowed to cool to room temperature, and two 0.5-in cores were removed from each chop parallel with the muscle fiber orientation. Each core was sheared once through the center with a Warner-Bratzler shear (WBS) force device attached to an Instron 4466 (Instron Corp., Canton, Maryland) with a 110-lb load cell and a crosshead speed of 250 mm/min.

All data were analyzed with the GLM procedure of SAS (1988) with magnesium-source as the main effect included in the model. Least-squares means for the main effect were calculated and separated using the least significant difference procedure of SAS (1988).

Results and Discussion

Magnesium supplementation, regardless of source, had no effect ($P > .10$) on CIE L*, a*, and b* values of the LM, TB, SM, and ST (Table 1), or calculated deoxymyoglobin, oxymyoglobin, and metmyoglobin content (Table 2) within any muscle measured. These findings conflict with the pork muscle color information from our laboratory (Maxwell et al., 1998; Apple et al., 1999). Maxwell et al. (1998) reported that inclusion of Magnesium-Mica in the diet of finishing swine resulted in improvements in subjective color evaluations. On the other hand, Apple et al. (1999) found that inclusion of Magnesium-Mica in the diet of finishing pigs reduced CIE a* and b* values (less red and less yellow, respectively) for pork LM. Also, there was some expectation that the high iron content of the MgO+FeS may increase myoglobin concentration or alter the oxymyoglobin content in muscle and improve muscle color; however, data from this study does not support this hypothesis.

The LM from lambs supplemented with UMM and WMM had less ($P < .05$) extractable lipid than the LM from lambs fed the control diet. Our finding conflicts with those of Coffey and Brazle (1995) and Coffey et al. (1995), who reported that intramuscular fat content, or marbling, was actually increased in the LM of cattle supplemented with magnesium. Although Mg source did not affect ($P > .10$) cooking loss percentages, the LM from lambs receiving UMM had higher ($P < .05$) shear force values compared to the LM from lambs receiving MgO+FeS, WMM, or C diets. There is no information available supporting or contradicting this result, and there does not appear to be a plausible explanation for this finding.

Implications

Neither magnesium supplementation or magnesium source had any appreciable effects on muscle color or muscle pigment state. On the other hand, carcasses from lambs supplemented with unweathered Magnesium-Mica had lower muscle lipid content, which could result in lower carcass quality grades and the associated economic discounts. The most disturbing finding was that feeding unweathered Magnesium-Mica resulted in less tender/tougher rib chops when compared to other magnesium sources. This may simply be a result of limited sample size, but further study is warranted.

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Table 1. Effect of magnesium source on CIE L*a*b* values[a].

	Magnesium source[b]				
	Ctrl	MgO+FeS	UMM	WMM	SE
Triceps brachii					
L*	34.90	32.54	33.92	33.10	0.71
a*	16.48	15.26	17.43	17.75	1.09
b*	12.22	10.75	12.98	13.28	1.14
Longissimus muscle					
L*	34.04	33.36	33.92	32.96	0.76
a*	17.24	16.36	16.01	17.06	0.92
b*	13.29	12.45	12.27	13.27	0.82
Semitendinosus					
L*	40.58	39.14	37.80	37.50	1.44
a*	16.34	18.03	16.82	14.98	1.11
b*	14.94	16.15	14.31	12.84	1.22
Semimembranosus					
L*	34.62	32.16	34.38	33.90	0.92
a*	15.69	17.16	16.39	15.06	1.21
b*	11.94	12.04	11.27	10.87	1.29

[a] L* = 0 is black and 100 is white; a* = red is positive and green is negative; and b* = yellow is positive and blue is negative.
[b] MgO+FeS = Magnesium oxide + iron sulfate; UMM = unweathered Magnesium-Mica; and WMM = weathered Magnesium-Mica.
No treatment effects were noted (P > .10).

Table 2. Effect of magnesium source on relative deoxy-, oxy-, and metmyoglobin content.

	Magnesium source[a]				
	Ctrl	MgO+FeS	UMM	WMM	SE
Triceps brachii					
Deoxymyoglobin[b]	1.068	1.074	1.056	1.064	0.008
Oxymyoglobin[c]	2.502	2.352	2.616	2.684	0.143
Metmyoglobin[d]	0.856	0.534	0.836	0.800	0.019
Longissimus muscle					
Deoxymyoglobin[b]	1.106	1.110	1.124	1.108	0.013
Oxymyoglobin[c]	2.630	2.516	2.524	2.646	0.121
Metmyoglobin[d]	0.786	0.804	0.818	0.788	0.017
Semitendinosus					
Deoxymyoglobin[b]	1.096	1.084	1.108	1.110	0.019
Oxymyoglobin[c]	2.384	2.610	2.362	2.284	0.147
Metmyoglobin[d]	0.812	0.800	0.806	0.818	0.010
Semimembranosus					
Deoxymyoglobin[b]	1.114	1.104	1.112	1.104	0.010
Oxymyoglobin[c]	2.384	2.586	2.442	2.282	0.179
Metmyoglobin[d]	0.816	0.812	0.808	08.32	0.018

[a] MgO+FeS = Magnesium oxide + iron sulfate; UMM = unweathered Magnesium-Mica; and WMM = weathered Magnesium-Mica.
[b] 474 nm:525 nm.
[c] 610 nm:525 nm.
[d] 572 nm:525 nm.
No treatment effects were noted (P > .10).

Table 3. Effect of magnesium source on longissimus muscle lipid content, cooking losses, and lamb tenderness.

	Magnesium source[a]				
	Ctrl	MgO+FeS	UMM	WMM	SE
Ether extractable lipid, %	3.39[b]	2.91[bc]	2.60[c]	2.40[c]	0.23
Cooking loss, %	12.77	12.74	12.07	12.44	0.59
Shear force, kg	4.13[b]	4.28[b]	5.99[c]	4.34[b]	0.38

[a] MgO+FeS = Magnesium oxide + iron sulfate; UMM = unweathered Magnesium-Mica; and WMM = weathered Magnesium-Mica.

[b,c] Within a row, least squares means lacking a common superscript letter differ ($P < .05$).


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