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Tyler E. Davis
University of Arkansas, Fayetteville

Elizabeth B. Kegley
University of Arkansas, Fayetteville

Kenneth P. Coffey
University of Arkansas, Fayetteville

Wayne K. Coblentz
University of Arkansas, Fayetteville

Robin K. Ogden
University of Arkansas, Fayetteville

See next page for additional authors

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Tyler E. Davis[*], *Elizabeth B. Kegley*[†], *Kenneth P. Coffey*[§], *Wayne K. Coblentz*[‡], *Robin K. Ogden*[§§], *and J. A. "Pete" Hornsby*[‡‡]

ABSTRACT

Two experiments were conducted to compare corn, dried distillers' grains (DDG), and pelleted soybean hulls (SH) as supplements for cattle grazing bermudagrass. In Exp. 1, 66 crossbred steers (306 ± 3.2 kg) were stratified by weight and allotted randomly to six 2.4-ha bermudagrass pastures for a 107-d study. One of three supplement treatments (corn, DDG, or SH) was assigned randomly to each pasture group and was offered at 0.5% (as fed) of body weight. Calves were weighed at 28-d intervals and supplement was adjusted after each weigh period. In Exp. 2, five ruminally cannulated steers grazed bermudagrass pasture and were individually fed supplements (corn, DDG, or SH) at 0.5% of body weight in a 3 x 3 replicated, incomplete Latin-square design with a 14-d adaptation and a 5-d sampling period. In Exp. 1, supplementation with DDG and corn increased ($P < 0.04$) the average daily gain compared to supplementation with SH (0.89, 0.87, and 0.74 kg for DDG, corn, and SH, respectively). In Exp. 2, in situ dry-matter-disappearance kinetic measures of bermudagrass were not affected by type of supplementation. The potential extent of digestion for DDG (93%) was lower than for corn (97%, $P = 0.01$) and SH (96%, $P = 0.06$). Supplementation with corn or DDG at 0.5% of body weight improved the gain of stocker cattle grazing bermudagrass compared to supplementation with SH, but these differences were not explained by differences in bermudagrass degradation kinetics.

[*] Tyler E. Davis is a senior majoring in animal science.

[†] Elizabeth B. Kegley is an associate professor in the Department of Animal Science and is the mentor for the project.

[§] Kenneth P. Coffey is a professor in the Department of Animal Science.

[‡] Wayne K. Coblentz is a former associate professor in the Department of Animal Science and is currently located at the USDA Dairy Forage Research Center in Marshfield, Wisc.

[§§] Robin K. Ogden is a program associate in the Department of Animal Science.

[‡‡] Pete Hornsby is a program associate in the Department of Animal Science.

INTRODUCTION

Arkansas ranks 16th in the United States in cattle and calf numbers with approximately 1.8 to 1.9 million head. These cattle have a cash value of more than $430 million and a total impact of $1.4 billion on the Arkansas economy (UACES, 2005). Additionally, Arkansas has approximately 420,000 stocker cattle and compared to data over past years, the number of stocker cattle continues to rise (USDA, 2005). Stocker calves are weaned beef calves (typically 136 to 272 kg) that graze forage generally and are provided supplements of grain to provide additional energy, protein, and minerals to achieve desirable gains.

The type of feed and its cost play a role in the profitability of the enterprise; therefore, new sources of low-cost highly nutritious supplemental feeds are constantly being sought. With the increasing number of ethanol plants (Tjardes and Wright, 2002) in the United States due to a demand for less dependency on foreign oil and more environmentally friendly energy, there is also an increasing amount of by-products. These by-products, known as distillers' grains, remain following the production of ethanol mostly from corn and contain high concentrations of protein and energy (Tjardes and Wright, 2002). However, phosphorus (P) concentrations in this by-product are well above cattle requirements and could potentially cause cattle-health (possible formation of urinary calculi) and environmental (P in run-off) problems (Tjardes and Wright, 2002). Distillers' grains have been used as an economical feed source for feedlot and dairy cattle for years; however, with this increasing supply, they may now be a more economical supplement for use in grazing animals.

There has been limited research investigating using distillers' grains as a supplement for calves grazing bermudagrass [*Cynodon dactylon*]. Bermudagrass can be

MEET THE STUDENT-AUTHOR

Upon graduation from Ashdown High School in May 2002, I enrolled at the University of Arkansas. My dream of being a "Razorback" was finally fulfilled. I was awarded the Honors College Academy Scholarship and the Alumni Society "Roads" Scholarship. In addition to these scholarships, I was fortunate to receive the Brandon Burlsworth Memorial Scholarship in 2005.

While on campus I have been actively involved with the Student Alumni Board, Pre-Dental Society, Associated Student Government, and served as President of the Block and Bridle Club. As a sophomore, I began working part-time on the Division of Agriculture Stocker-Receiver Beef Unit under the direction of Pete Hornsby and my mentor, Dr. Beth Kegley.

Tyler E. Davis

Being from a strong agricultural background, I have always possessed a passion for agriculture. My family owns and operates a commercial cow-calf and stocker cattle operation in rural Little River County, and I also own a herd of registered Angus cattle. This research project presented me with an opportunity to expand my knowledge and explore other aspects of the cattle and agricultural industries.

I am a senior majoring in animal science and will graduate with honors in May 2006. I have been accepted at the University of Tennessee-Memphis College of Dentistry and plan to specialize in pediatric dentistry.

I would like to thank especially Dr. Beth Kegley for her support and guidance as well as Dr. Ken Coffey for his research expertise. Additionally, I would like to thank Doug Galloway, Pete Hornsby, and Robin Ogden for their assistance during my research trial. All of those involved are greatly appreciated.

found on many farms in Arkansas; it is estimated that over 2 million acres of bermudagrass exist in the state (UACES, 2006). Although soil fertility, rainfall, and maturity affect bermudagrass nutritive value, the high fiber content of bermudagrass limits optimal calf growth. Calves grazing bermudagrass generally respond positively to supplementation of energy provided from grains. Yet, high levels of starch-containing grains, such as corn, decrease forage intake and fiber digestion of forage-based diets if supplemented at higher levels (Garces-Yepez et al., 1997). Soybean-hull pellets are a locally available by-product of milling soybeans; these pellets are low in starch and thus provide energy without possible negative impacts on fiber digestion (Galloway et al., 1993). A comparison of these feedstuffs (distillers' grains, soybean-hull pellets, and corn) in growing cattle would provide important information for Arkansas producers and allow them to make more informed and economical supplementation choices. Therefore, objectives in this study were to determine the impact of providing cattle with supplements of corn, dried distillers' grains (DDG), or soybean-hull pellets (SH) on growth performance, blood metabolites and ruminal-forage degradation kinetics in cattle grazing bermudagrass pastures.

MATERIALS AND METHODS

There were two phases of this project. Experiment 1 was conducted to evaluate corn, DDG, and SH as protein and energy sources for stocker cattle grazing bermudagrass as well as to determine if supplementation influenced blood metabolites. Experiment 2 was conducted to evaluate the impact of these same supplements on ruminal digestibility of these supplements as well as bermudagrass pasture samples, using an in situ procedure. All procedures involving steers were approved by the University of Arkansas Animal Care and Use Committee.

Experiment 1: Sixty-six crossbred steers (initial body weight averaged 306 ± 3.2 kg) were stratified by weight and allotted randomly to six 2.4-ha pastures at the University of Arkansas Stocker-Receiving Unit near Savoy, Ark. on 11 May 2005. Calves had ad libitum access to fresh water and were monitored daily for morbidity. One of three supplement treatments (corn, DDG, or SH) was assigned randomly to each pasture group and steers were offered these supplements at 0800 h daily at a rate of 0.5% (as fed) of body weight. Pastures were predominately bermudagrass (14.7% crude protein, 68% neutral digestible fiber, 32% acid detergent fiber, 0.39% P) and averaged 6,377 kg/ha of available forage over the 107-d study. Calves were weighed at 28-d intervals and the amount of supplement offered was adjusted after each weigh period such that calves were offered 0.5% of body weight; any supplement refusals were recorded daily. Supplement samples were collected every 28 d and were analyzed for crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), and P on a dry-matter (DM) basis.

Cattle were weighed at the beginning and end of the trial on two consecutive days, and interim weights were taken every 28 d. Blood samples were collected on d 0, 28, 56, 84, and 107 via jugular venipuncture with vacuum tubes. These samples were stored on ice after collection until centrifuged at 1,200 x g for 20 min for separation of serum or plasma; then serum or plasma samples were stored frozen (-20°C) until analyzed. Samples for serum urea nitrogen concentrations were collected into glass tubes containing a clot activator (BD Vacutainer®, Franklin Lakes, N.J.) and analyzed with a colorimetric assay (L-Type UN kit, Wako Chemicals USA, Inc., Richmond, Va.). Samples for serum P concentrations were also taken in tubes with the clot activator; serum was deproteinated with 10% trichloroacetic acid and then P was determined with a colorimetric procedure (Bodine and Purvis, 2003). Samples for plasma non-esterified fatty acid (NEFA) concentrations were taken in tubes with EDTA (BD Vacutainer®). Plasma was analyzed with a commercial colorimetric assay (NEFA-C kit, Wako Chemicals USA, Inc., Richmond, Va.).

Fecal grab samples were taken from four calves per pen on d 84 and 107 and stored frozen to examine fecal P concentrations. Fecal material was later thawed, dried, ground to pass through a 1-mm screen of a Wiley Mill, sub-sampled, wet-ashed with nitric acid, and P determined with a colorimetric assay (Bodine and Purvis, 2003). Additionally, forage availability was measured every 28 d with a calibrated, rising disk meter, and grab samples were taken and combined in a composite sample to determine CP, NDF, ADF, and P.

Steer weights, average daily gain, blood metabolites, and fecal P were statistically analyzed using PROC MIXED of SAS (SAS Inst., Cary, N.C.). The experimental unit was a pen. A repeated statement was used for blood data.

Experiment 2: In a replicated incomplete 3 x 3 Latin square design, five ruminally cannulated crossbred (Gelbvieh x Angus x Brangus) steers (initial weight averaged 794 kg) grazed a bermudagrass pasture (1.46 ha) and had ad libitum access to fresh water. Steers were weighed at the beginning and end of each period. Each period consisted of 19 d, with 14 d of supplement adaptation followed by 5 d of in situ procedure. Period 1 began on 28 June 2005. Steers were caught daily at 0800 h and fed each of the supplements used in Exp. 1 (Table 1) at 0.5% (as fed) of body weight.

Bermudagrass was collected immediately prior to Period 1 of in situ collection from the same pasture the steers were grazing. In situ procedures were used as

described by Vanzant et al. (1998). Dacron bags (10 x 20 cm; 53 ± 10-µm pore size; Ankom Co., Fairport, N.Y.) were filled with 5 g (as-fed) of dried (50°C), ground (to pass through a 2-mm screen of a Wiley mill) bermudagrass, or the appropriate supplement then heat sealed to determine in situ DM digestibility. All Dacron bags for each time period were placed in mesh laundry bags (35- x 50-cm), pre-incubated in tepid (39°C) water for 20 min to decrease the lag time associated with microbial attachment, and then inserted (except for 0 h) into the ventral rumen prior to the morning feeding. Bags containing the appropriate supplement were removed at 0, 3, 6, 9, 12, 18, 24, 36, 48, and 72 h after insertion. Bags containing dried bermudagrass were removed at 0, 6, 9, 12, 18, 24, 48, 72, 96, and 120 h after insertion. All bags were rinsed five times with tap water, then five times with deionized water, in a top-loading washing machine with a 1 min agitation and a 2 min spin per rinse to remove particles adhering to the outside of bags as outlined by Coblentz et al. (1997) and Ogden et al. (2005). Bags were dried under forced air for at least 48 h at 50°C and then weighed after equilibration with atmospheric moisture. Dry-matter disappearance was calculated as the dry weight remaining minus the initial dry weight in each bag. Ruminal disappearance data were fitted to the non-linear regression model of Mertens and Loften (1980). Fraction A represented the immediately soluble portion, Fraction B was defined as the portion of DM that disappeared at a measurable rate, and Fraction U represented the portion that was undegradable in the rumen. Potential extent of digestion was calculated as 100 minus U. Kinetic parameters (B, U, digestion lag time [L], and rate of disappearance [k_d]) were estimated using PROC NLIN of SAS (SAS Inst., Cary, N.C.). After parameters were estimated, treatment comparisons were made using PROC MIXED of SAS where the model included animal, period, and treatment.

RESULTS AND DISCUSSION

Experiment 1: Steer weights were not different until d 107, when steers supplemented with corn and DDG weighed more than steers supplemented with SH ($P < 0.04$) (Fig. 1). Average daily gains of steers supplemented with corn (0.87 kg) and DDG (0.89 kg) were greater than average daily gains of steers supplemented with SH (0.74 kg; $P < 0.04$) for the 107-d trial. These lower average daily gains in steers supplemented with SH differ from the results of Anderson et al. (1988) and Garces-Yepez et al. (1997). They reported similar average daily gains for cattle supplemented with corn versus SH. In the current study, supplement type did not affect forage availability in the pastures, and forage availability was never limiting (minimum observed was 3,080 kg DM/ha).

There was a main effect of supplement type on serum urea-N (Fig. 2). Steers supplemented with DDG had the greatest serum urea-N concentrations, steers supplemented with SH had intermediate concentrations, and steers supplemented with corn had the lowest concentrations of serum urea-N ($P < 0.01$). This was due to the greater amount of CP that the DDG and SH contained as compared to corn (Table 1). This excess protein was degraded in the rumen and the ammonia was absorbed across the rumen wall. The liver detoxified the ammonia by forming urea that circulates in the bloodstream until being excreted in the urine (Church, 1988). Because of the high level of CP in the bermudagrass, none of these steers, even those supplemented with corn, should have been deficient in protein. All of these serum urea-N concentrations are considered high for cattle, and the concentrations for the steers supplemented with DDG were approaching levels that may cause decreased fertility for heifers of breeding age (Elrod and Butler, 1993).

Concentrations of plasma NEFA (Fig. 3) were not different among treatment sources. Plasma NEFA concentrations are increased when fat stores are being metabolized. Concentrations of NEFA were greatest on d 0, before supplementation started, and were low for the remainder of the experiment, indicating that energy was not limiting for these growing steers (Clarenburg, 1992).

There was a treatment x day interaction ($P < 0.05$) for serum-P concentrations (Fig.4). Serum-P concentrations were consistent until d 107, when steers supplemented with corn had lower concentrations of serum P than steers supplemented with DDG or SH.

There was a main effect of supplement source and day on fecal-P concentrations ($P < 0.003$). Steers supplemented with DDG had the greatest fecal-P concentrations (0.84%), corn supplemented steers were intermediate (0.70%) and did not differ from that of steers supplemented with SH who had the lowest concentrations of fecal-P (0.66%) (data not shown). These results were expected due to DDG having a greater concentration of P, corn being intermediate, and SH containing the lowest P concentration. Fecal-P concentrations also varied by day, with concentrations on d 84 (0.70%) being lower than concentrations on d 107 (0.84%). This probably reflected the increased supplement intake during this last month of the study and also was due to an increased concentration of P in the bermudagrass during this last period due to regrowth after a rain event.

Experiment 2: There were no effects of supplement type on ruminal disappearance of bermudagrass (Table 2). These results agree with the results of Garces-Yepez et al. (1997) where sheep were fed a corn-based supplement or SH at a similar rate as in this study and no suppression of ruminal organic-matter digestibility was observed.

However, Galloway et al. (1993) showed a decrease in bermudagrass hay intake and NDF digestion when cattle were supplemented with corn at 0.5% of body weight.

Ruminal disappearances of supplements were different among sources, with DDG having the greatest A fraction, corn intermediate, and SH having the smallest ($P < 0.01$) (Table 2). Soybean hulls had the greatest B fraction ($P < 0.01$), corn was intermediate, and DDG the smallest. Rate of disappearance (k_d) did not differ between DDG and SH, yet both rates were lower than that of corn ($P < 0.01$). Lag times were greatest ($P < 0.01$) from SH, intermediate from DDG, and smallest from corn. The potential extent of ruminal disappearance was greater for corn ($P < 0.03$) than for DDG with SH being intermediate and not different from either corn or DDG. However, all potential extents of ruminal disappearance were greater than 92%.

In conclusion, supplementation with corn or DDG at 0.5% of body weight improved average daily gains of stocker cattle grazing bermudagrass compared to supplementation with SH. However, in situ disappearance of bermudagrass was not different when these supplements were fed at the rate of 0.5% of body weight daily. All these supplement types produced desirable rates of gain for stocker cattle grazing bermudagrass in Arkansas.

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Table 1. Nutrient composition of supplements fed to steers grazing bermudagrass pasture.

	CP	NDF	ADF	P
	----------% of DM----------			
Corn	9.0	13.3	3.0	0.14
Distillers grains	29.0	45.3	17.6	0.72
Soybean hulls	12.1	65.3	47.4	0.11

Table 2. In situ disappearance kinetics of bermudagrass forage and supplements for steers grazing bermudagrass pasture in Exp. 2.

	Fraction A[1]	Fraction B[1]	Fraction U[1]	Lag time	K_d[2]	Potential Extent[3]
	----------% of DM----------			h	/h	%
Bermudagrass						
Corn	18.6	52.3	29.1	0.75	0.032	70.9
Distillers grains	17.2	52.2	30.6	1.15	0.038	69.4
Soybean hulls	17.3	52.2	30.5	1.33	0.038	69.5
P-value	0.32	0.99	0.29	0.67	0.38	0.29
SEM[4]	0.64	1.08	0.65	0.46	0.0033	0.65
Supplement						
Corn	32.7[b]	64.3[b]	3.0	0.4[f]	0.108[a]	97.0[d]
Distillers grains	37.2[a]	55.6[c]	7.2	1.4[e]	0.043[b]	92.9[e]
Soybean hulls	14.4[c]	81.1[a]	4.5	4.5[d]	0.055[b]	95.6[de]
P-value	<0.0001	<0.0001	0.034	0.0111	0.0011	0.034
SEM[4]	0.77	0.97	0.84	0.65	0.007	0.84

[1]Fraction A = immediately soluble fraction, B = fraction disappearing at a measurable rate, and U = undegrade
[2]K_d = ruminal disappearance rate
[3]Calculated as (100-U)
[4]Standard error of the mean
[abc]$P < 0.01$
[def]$P < 0.05$

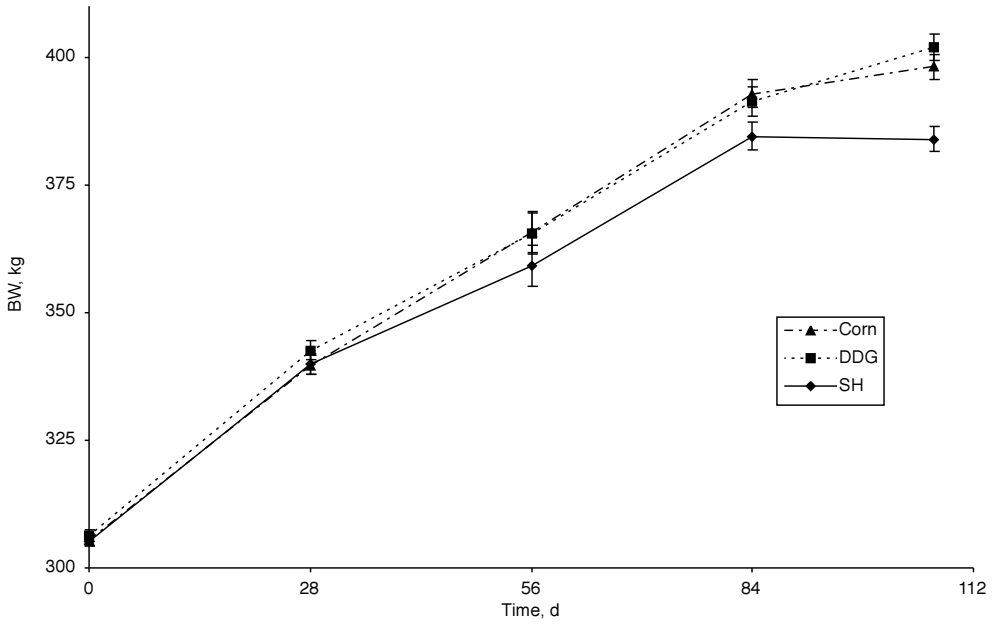

Fig. 1. Effect of supplement source on performance of steers grazing bermudagrass pastures in Exp. 1 throughout a 107-d trial. DDG = dried distillers' grains; SH = soybean hulls.

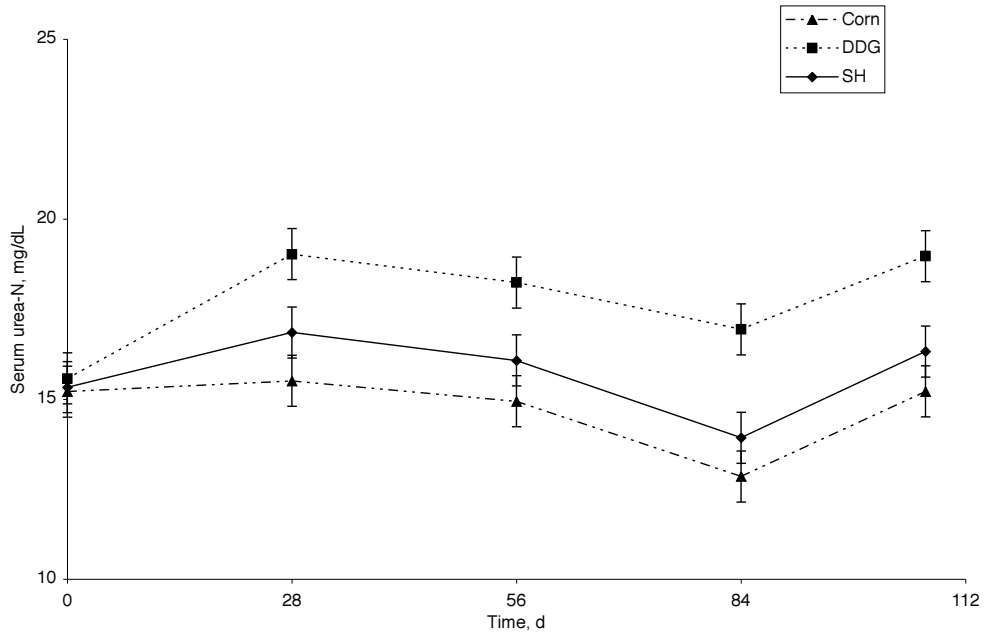

Fig. 2. Effect of supplement source on serum urea-N concentrations from steers grazing bermudagrass pastures in Exp. 1. DDG = dried distillers' grains; SH = soybean hulls.

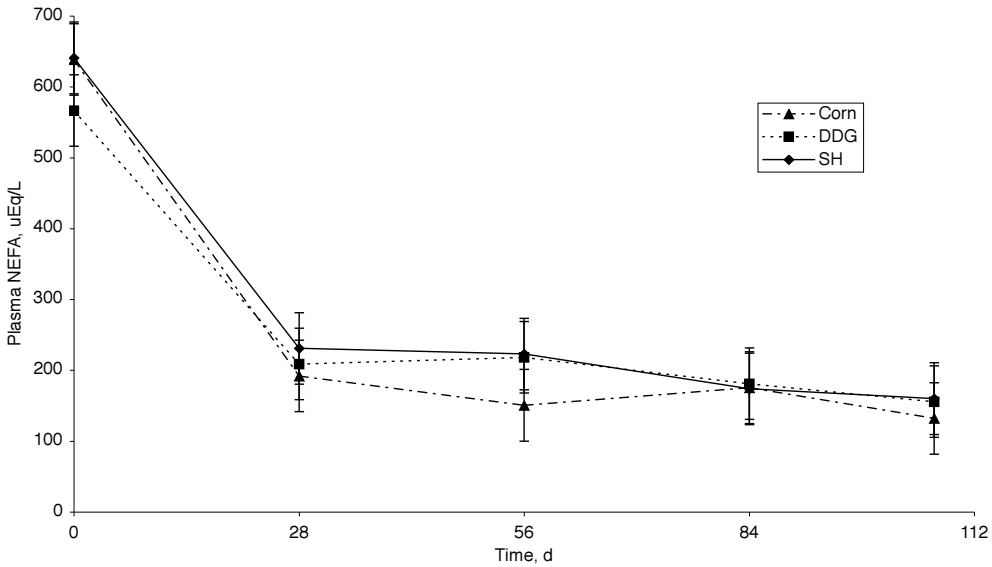

Fig. 3. Effect of supplement source on plasma NEFA concentrations from steers grazing bermudagrass pastures in Exp. 1. DDG = dried distillers' grains; SH = soybean hulls.

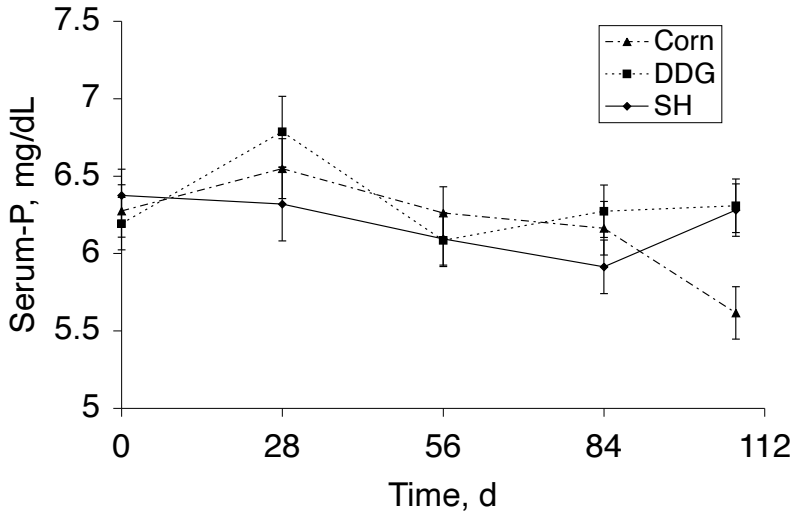

Fig. 4. Effect of supplement source on serum-P concentrations from steers grazing bermudagrass pastures in Exp. 1. DDG = dried distillers' grains; SH = soybean hulls.