July 2007

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Utilization of dried distillers grains for developing beef heifers[1,2,3]

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ABSTRACT: A 2-yr study was conducted at 2 locations to determine if supplementing beef heifers with dried distillers grains (DDG) as an energy source affected growth or reproduction. Spring-born crossbred heifers (n = 316) were blocked by age or sire and age and assigned randomly to DDG or control (dried corn gluten feed, whole corn germ, urea) supplement. Heifers received prairie hay in amounts sufficient for ad libitum intake and 0.59% of BW DDG or 0.78% of BW control supplement (DM basis). Supplements were formulated to be isocaloric, but protein degradability differed. Supplemental undegradable intake protein intake from DDG averaged 267 g/animal daily and reached 318 g/animal daily; control supplemental undegradable intake protein intake averaged 90 g/animal daily and peaked at 107 g/animal daily. Initial pubertal status was determined by 2 blood samples collected 10 d apart, and monthly BW were collected from November through January; then biweekly BW and blood samples were collected from February until May yearly. Heifers were synchronized with 2 injections of $PGF_{2\alpha}$ 14 d apart; estrus was detected and heifers were artificially inseminated for 5 d and placed with bulls 10 d later. Conception and pregnancy rates were determined via transrectal ultrasonography. Initial age, BW, and BCS did not differ ($P > 0.92$) for control and DDG heifers. Final BW, ADG, and final BCS also were not affected ($P > 0.31$) by supplementation. Estimated age and BW at puberty did not differ ($P > 0.23$) between treatments, and the proportions of pubertal heifers did not differ at the initiation of the experiment ($P > 0.82$), at the beginning of the 14-d sampling intervals, or before synchronization. Estrus synchronization rate (75.9%), time of estrus, and overall pregnancy rate (89.5%) were not affected ($P > 0.14$) by treatment. However, a greater proportion ($P = 0.008$) of DDG than control heifers conceived to AI (75.0 vs. 52.9%), resulting in greater ($P = 0.07$) AI pregnancy rates for DDG heifers (57.0 vs. 40.1%). Body weight or BCS at pregnancy diagnosis did not differ ($P > 0.52$) between DDG and control heifers. Supplementing beef heifers with DDG during development did not affect age at puberty but improved AI conception and pregnancy rates compared with an isocaloric control supplement.

Key words: beef cattle, dried distillers grain, heifer development, puberty, reproduction, undegradable intake protein

J. Anim. Sci. 2007. 85:2298–2303
doi:10.2527/jas.2007-0076

INTRODUCTION

The majority of replacement beef heifers developed in the Midwest are fed forage-based diets supplemented with protein and energy to achieve traditional target weights of 60 to 65% of mature BW (Patterson et al., 1992). In forage-based diets, dried distillers grains (**DDG**) have greater energy value than corn (Loy et al., 2003). Crude protein concentration of DDG is nearly 30%, with approximately 50% or more of CP in the form of undegradable intake protein (**UIP**; Benton et al., 2006). Dried distillers grains also have relatively high concentrations of P, which reduces or eliminates the need for supplemental P with many forage diets (NRC, 2000). Development of new ethanol plants is likely to increase the proportion of corn grown in the Midwest used for ethanol production by the corn dry-milling industry. Therefore, DDG may be economically feasible as the primary source of energy and protein for growing replacement heifers.

When DDG are fed as an energy source in growing heifer diets, UIP is commonly supplied in excess of re-

[1]A contribution of the University of Nebraska Agricultural Research Division, supported in part by funds provided through the Hatch Act. Mention of a trade name, proprietary products, or company name is for presentation clarity and does not imply endorsement by the authors or the University of Nebraska.

[2]The authors wish to thank Dakota Gold Marketing, Sioux Falls, SD; Cargill Inc., Blair, NE; Archer Daniels Midland Company, Columbus, NE; and IVX Animal Health, St. Joseph, MO, for donation of products.

[3]The authors wish to acknowledge the financial support of the Nebraska Center for Energy Sciences Research and the Nebraska Public Power District, which partially funded this study.

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Received February 1, 2007.
Accepted May 13, 2007.

Table 1. Supplement composition (DM basis) and daily intake

Item	Control[1]	DDG[2]
Ingredient, %		
Dried distillers grains		99.76
Dried corn gluten feed	73.00	
Whole corn germ	24.48	
Urea	2.33	
Trace mineral premix[3]	0.16	0.20
Vitamin ADE premix[4]	0.03	0.04
Daily supplement rate, % of BW	0.78	0.59
Diet CP,[5] %	15.2	14.8
Avg. daily UIP intake,[6] g	90	267
Maximum daily UIP intake,[7] g	107	318
MP balance,[8] g/d	44	180
DIP balance,[8] g/d	176	–32

[1]Supplemented daily with control supplement at 0.78% of BW.
[2]Supplemented daily with dried distillers grains supplement at 0.59% of BW.
[3]Contained 13 to 15% Ca, 12% Zn, 8% Mn, 10% Fe, 1.5% Cu, 0.2% I, and 0.1% Co.
[4]Contained 6,185,455 IU/kg of vitamin A; 1,237,090 IU/kg of vitamin D_3; and 1,545 IU/kg of vitamin E.
[5]Diet CP calculated using NRC (2000) model level 1.
[6]Daily UIP intake averaged across the length of the experiment.
[7]Maximum UIP intake achieved at the conclusion of the experiment.
[8]Predicted MP and degradable intake protein balances calculated using NRC (2000) model level 1, predictions based on actual ADG, midtest BW, and forage value.

quirements. Supplementation of prepubertal heifers with 421 g of UIP/d, primarily from blood meal, increased BW at puberty compared with control heifers fed 231 g UIP/d; high UIP heifers also had increased age at puberty compared with heifers fed the control supplement plus monensin (Lalman et al., 1993). In the same study, fewer heifers fed high UIP supplements were detected in estrus during the first 21 d of the breeding season, but pregnancy rates did not differ. Additionally, supplementing postpubertal heifers with high UIP (321 g/d), mainly from feathermeal and fishmeal, decreased serum concentrations of FSH compared with heifers consuming 115 g/d UIP (Kane et al., 2004).

The objective of this study was to determine if supplementing beef heifers with excess UIP from DDG during development affects heifer growth or reproduction.

MATERIALS AND METHODS

Heifers

All procedures were approved by the University of Nebraska Institutional Animal Care and Use Committee. In each of 2 yr, weaned heifer calves (n = 316) were stratified by age at location 1 (n = 151; University of Nebraska Dalbey-Halleck farm, Virginia, NE) and by age by sire at location 2 (n = 165; University of Nebraska Agricultural Research and Development Center, Ithaca, NE), and assigned randomly to receive DDG or control supplement (Table 1) during development. Heifers from location 1 were of composite Angus × Simmental and Angus × Gelbvieh genetics. At location 2, composite MARC III (¼ Angus, ¼ Hereford, ¼ Red Poll, ¼ Pinzgauer) × Red Angus heifers were utilized. Heifers were weaned in mid October yearly at an average age of 200 d, and supplementation began in mid November at an average age of 239 d. Between weaning and initiation of the experiment, heifers at location 1 were maintained in a drylot and offered ad libitum access to prairie hay. Heifers at location 2 were allowed to graze cool-season pasture between weaning and the beginning of the experiment. The supplementation period was 196 d in yr 1 and 190 d in yr 2, concluding in late May yearly.

Table 2. Hay nutrient analysis (DM basis) by year and location[1]

Year	Location	CP, %	TDN, %	NDF, %	ADF, %
1	1	8.4	53.9	66.9	43.6
1	2	11.0	54.0	71.1	43.4
2	1	8.0	54.7	63.6	42.8
2	2	8.6	53.6	70.1	43.8

[1]Samples were analyzed by the University of Nebraska Soil and Plant Analysis Laboratory (Lincoln, NE) using an NIRS 5000 (Foss North America, Inc., Eden Prairie, MN) machine.

Initial and final BW were taken on 2 consecutive days, and heifers were not limit-fed before weighing. Body condition scores (1 = emaciated, 9 = obese; Wagner et al., 1988) were assigned independently by 2 trained technicians, and the average of those scores was used for data analysis. Interim BW were collected monthly until mid February of each year, and beginning in mid February weights were collected every 14 d until completion of the experiment.

Supplementation

During the supplementation phase of the experiment, heifers were maintained in drylots and allowed ad libitum access to prairie hay (Table 2). Hay intake was not quantified. Hay samples were analyzed by the University of Nebraska Soil and Plant Analysis Laboratory (Lincoln, NE) using an NIRS 5000 (Foss North America Inc., Eden Prairie, MN) machine to determine forage nutrient concentration. Results of hay analysis for each location and year are presented in Table 1.

Supplement composition, daily intake, and predicted protein balance (NRC, 2000) are presented in Table 2. Dried distillers grains (27.7% CP, 53.9% of CP as UIP, on a DM basis) were acquired from Dakota Gold Marketing, Sioux Falls, SD. The control supplement was primarily dried corn gluten feed pellets (20.4% CP, 20.8% of CP as UIP; Cargill Inc., Blair, NE) and whole corn germ (13.6% CP, 21.5% of CP as UIP; Archer Daniels Midland Company, Columbus, NE) to provide a similar source of digestible fiber and lipid. Each of the ingredients was received in 2 loads during yr 1 and a single load during yr 2. Samples were collected from each load for nutrient analysis. Supplementation rate

was based on BW, so that relative supplemental CP, energy, and lipid intake were similar between groups. An ADG of 0.68 kg/d was targeted to achieve approximately 60% of mature BW at the time of breeding. Protein degradability of the supplements differed, such that UIP was fed in excess of requirements (NRC, 2000) for DDG heifers.

Supplements were bagged in approximately 22.7-kg bags. Heifers were fed daily in their respective groups with 0.5 m or more of bunk space per heifer. Supplement was offered at 0.78% of BW for control and 0.59% of BW for DDG heifers and adjusted after each weigh date. Each group was fed their respective supplement through the last day of AI, at which time heifers at each location were placed in a single group on cool-season pastures containing predominantly smooth brome grass (*Bromus inermis* Leyss.) and Kentucky bluegrass (*Poa pratensis* L.).

Blood Collection and Assay Procedures

Blood samples were collected via coccygeal venipuncture into tubes containing liquid K_3EDTA (BD Vacutainer, BD Diagnostics, Franklin Lakes, NJ) and cooled immediately on ice. Plasma was harvested via centrifugation within 4 h of collection and frozen at –20°C until analysis. Plasma concentrations of progesterone were determined by direct solid-phase RIA (Coat-A-Count, Diagnostics Products Corp., Los Angeles, CA), with modifications described by Melvin et al. (1999). Intra- and interassay CV (n = 7 assays) for samples from yr 1 were 3.1 and 6.8%, respectively. Samples from yr 2 were evaluated in 10 assays, with intra- and interassay CV of 4.6 and 8.0%, respectively.

Initial pubertal status of heifers was determined in November, immediately before initiation of supplementation. Two blood samples were collected 10 d apart, and plasma concentrations of progesterone were utilized to determine the proportion of heifers pubertal before treatment. Further blood sampling began in mid February yearly, with blood samples collected every 14 d to determine approximate age at puberty. Concentrations of progesterone greater than 1 ng/mL were interpreted to indicate ovarian luteal activity and therefore attainment of puberty.

Estrus Synchronization and Artificial Insemination

Estrus was synchronized using 2 injections of $PGF_{2\alpha}$ (**PGF**; Prostamate, IVX Animal Health, St. Joseph, MO) administered 14 d apart. Injections were given i.m. in the neck. Estrus detection was performed for at least 1 h in the early morning and late evening for 5 d after the second PGF injection. Heifers observed in estrus received AI approximately 12 h later. Within year, a single AI service sire was used at location 1 and 2 sires were used equally across treatments at location 2. Heifers were exposed to fertile bulls for approximately 45 d beginning 10 d after final AI. Conception rate to AI was determined via transrectal ultrasonography approximately 45 d after AI. An additional ultrasound pregnancy diagnosis was performed 45 d after removal of bulls to determine the final pregnancy rate.

In Situ UIP Determination

Undegradable intake protein content of supplement ingredients was determined using a 16-h in situ procedure. Sample preparation varied with feedstuff. Dried distillers grains were placed directly into Dacron bags without processing. Whole corn germ was ground to pass through a 2-mm screen before incubation. Dried corn gluten feed pellets were incubated as whole pellets and coarsely ground (4-mm screen) for each sample because grinding of the pellets through a 2-mm screen resulted in nearly complete washout in the rumen. In yr 1, approximately 10 g of sample was weighed into 10×20-cm bags with a 50-μm pore size. In yr 2, approximately 2 g of sample was used in 5×10-cm bags with the same pore size. Although sample size was different between years, Whittet et al. (2002) determined that sample size did not affect in situ UIP estimation. Samples from each year were incubated in duplicate for 0 and 16 h in the ventral rumen of a single donor. After retrieval from the rumen, the bags were gently hand-washed, dried for 12 h in a 60°C forced-air oven, and the residue was weighed. Protein content of feedstuffs and residue was determined using a Leco N analyzer (Leco Corp., St. Joseph, MI). Calculated UIP content (% of CP) of feedstuffs was determined as the ratio of CP in the residue remaining after in situ incubation compared with the CP in the unincubated feedstuff.

Statistical Analysis

Data were analyzed using PROC MIXED (SAS Inst. Inc., Cary, NC). Treatment group within year and location (n = 4 replications per treatment) was the experimental unit. The model included treatment, location, and the interaction of treatment and location. Year was included as a random effect. Least squares means were compared using the PDIFF option of SAS. Percentage of heifers reaching puberty, estrus synchronization response, conception rate, and pregnancy rates were analyzed after logit transformation using PROC MIXED as previously described (Cox, 1988; Martin et al., 2005). Technician and service sire were included in the initial model for AI conception and pregnancy rates but were removed from the final model because they were not significant.

RESULTS AND DISCUSSION

Heifers supplemented with DDG consumed an average of 267 g/animal daily supplemental UIP. At the end of the supplementation period, at approximately the time of breeding, supplemental UIP intake reached 318

Table 3. Effects of dried distillers grains (DDG) supplementation during development on growth performance of composite beef heifers

	Location 1		Location 2			*P*-value[1]		
Trait	Control[2]	DDG[3]	Control[1]	DDG[2]	SEM	Trt	Loc	T × L
No. of heifers	75	76	82	82	—	—	—	—
Initial age, d	250[a]	250[a]	230[b]	230[b]	2	0.93	0.002	0.99
Initial wt, kg	257	256	247	248	13	0.98	0.52	0.96
Initial BCS	5.32	5.32	5.37	5.36	0.07	0.96	0.54	0.93
Final wt, kg	376	373	360	381	17	0.64	0.83	0.53
Final BCS	5.66	5.71	5.56	5.65	0.12	0.60	0.56	0.85
ADG, kg	0.65	0.64	0.60	0.72	0.04	0.32	0.71	0.24

[a,b]Within a row, means without common superscripts differ at $P < 0.05$.
[1]Trt = treatment main effect; Loc = location main effect; and T × L = treatment × location interaction.
[2]Supplemented daily with control supplement at 0.78% of BW.
[3]Supplemented daily with DDG supplement at 0.59% of BW.

g/animal daily. The NRC (2000) model level 1 predicted a MP balance of 180 g/d for DDG heifers. However, the model assumes 80% digestibility for all UIP sources. Benton et al. (2006) reported UIP digestibility of DDG to be 88.8%. Therefore, it seems likely the MP balance reported in Table 2 is underestimated.

Heifer performance and BCS data are presented in Table 3. Age at the beginning of the study did not differ ($P = 0.93$) between groups but differed ($P < 0.002$) by location; heifers at location 1 averaged 250 ± 2 d of age and heifers at location 2 averaged 230 ± 2 d of age. Initial BW and BCS did not differ ($P > 0.95$) between control and DDG heifers and averaged 252 ± 13 kg of BW and 5.34 ± 0.07 BCS. Heifer BW at conclusion of supplementation was not affected ($P > 0.63$) by treatment or location. Final BW after supplementation averaged 373 ± 17 kg. At location 1, ADG were similar ($P = 0.86$) for DDG and control heifers (0.64 ± 0.04 kg vs. 0.65 ± 0.04 kg, respectively). Heifers at location 2 supplemented with DDG also had similar ($P = 0.16$) ADG to control and averaged 0.72 ± 0.04 kg and 0.60 ± 0.04 kg, respectively. Treatment did not ($P = 0.60$) influence BCS at the end of the supplement period and averaged 5.7 ± 0.1 for DDG heifers and 5.6 ± 0.1 for control heifers.

At initiation of the experiment in mid November, 8.9% of control and 7.6% of DDG heifers were pubertal (Table 4; $P = 0.93$). In mid February, when blood sampling began at 14-d intervals, 49.0% of control and 43.1% of DDG heifers were pubertal ($P = 0.83$). Proportions of control and DDG heifers that achieved puberty before synchronization did not differ ($P = 0.95$; 86.1 and 77.2%, respectively). Age at puberty was not affected ($P = 0.68$) by treatment and averaged 353 ± 24 d for control and 358 ± 24 d for DDG heifers. Body weight at puberty did not differ ($P = 0.24$) for DDG heifers and control heifers. Our initial hypothesis was DDG heifers would be older and heavier at puberty than control heifers based on previous research (Lalman et al., 1993) feeding high UIP supplements to developing heifers. Heifers fed 421 g of UIP/d were older and heavier at puberty than heifers fed 231 g of UIP/d or heifers fed 238 g of UIP/d plus 200 mg of monensin/d (Lalman et al., 1993). One notable difference between this study and the current experiment is the source of UIP. Dried distillers grains provided all of the supplemental UIP in the current study, in contrast to blood meal as the primary UIP source in the Lalman et al. (1993) study. Results from the current study indicate feeding UIP from DDG above NRC recommendations does not delay puberty.

The proportion of heifers responding to estrous synchronization within 5 d of the second PGF injection was not different (Table 4; $P = 0.94$) between treatments. The mean time between final PGF injection and detected estrus was not affected ($P = 0.15$) by treatment, but estrus occurred earlier ($P = 0.05$) at location 1 than 2. These results disagree somewhat with previous research that found a lower proportion of heifers supplemented with excess UIP from blood meal were detected in estrus during the initial 21 d of the breeding season compared with control heifers fed balanced degradable intake protein (**DIP**) and UIP (Lalman et al., 1993).

Lalman et al. (1993) reported similar pregnancy rates for heifers fed a high UIP supplement vs. those fed a supplement balanced for protein degradability. Kane et al. (2004) supplied postpubertal heifers 321, 216, or 115 g/d of UIP, mainly from feather meal and fishmeal. Heifers supplemented with 321 g of UIP/d had increased follicular fluid IGFBP-2 and IGFBP-4 on d 12 to 14 of the estrous cycle, lower basal serum FSH, and reduced FSH area under the curve compared with heifers fed 115 g of supplemental UIP/d, indicating high UIP intake may impair gonadotropin secretion and follicle development. In the current study, 75.0% of DDG heifers conceived to AI service, compared with 52.9% of control heifers ($P = 0.008$). Therefore, AI pregnancy rate for DDG heifers was 57.0% and was greater ($P = 0.07$) than AI pregnancy rate of control heifers (40.1%). Other studies have reported positive effects of high UIP supplements on reproduction. In pregnant heifers supplemented during late gestation and young postpartum cows, supplementation with high UIP feeds tends to improve subsequent reproductive performance when

Table 4. Effects of dried distillers grains (DDG) supplementation during development on pubertal development, estrus synchronization response, and reproductive performance of composite beef heifers

	Location 1		Location 2			*P*-value[1]		
Trait	Control[2]	DDG[3]	Control[2]	DDG[3]	SEM	Trt	Loc	T × L
No. of heifers	75	76	82	82	—	—	—	—
Pubertal in November,[4] %	12.0	9.2	6.0	6.1	—	0.93	0.44	0.78
Pubertal in February,[5] %	64.0	52.6	36.1	34.1	—	0.83	0.46	0.88
Pubertal before $PGF_{2\alpha}$,[6] %	100.0[a]	98.7[a]	56.6[b]	74.4[b]	—	0.95	0.05	0.51
Age at puberty, d	351	359	355	357	12	0.68	0.96	0.80
BW at puberty, kg	315	320	314	339	24	0.24	0.44	0.40
Estrus response,[7] %	82.7	77.6	69.5	74.4	—	0.94	0.17	0.34
Time of estrus,[8] h	65.4[a]	64.0[a]	78.1[b]	69.1[b]	6	0.15	0.05	0.26
AI conception rate,[9] %	50.0[a]	71.2[b]	56.1[a]	78.7[b]	—	0.008	0.16	0.99
AI pregnancy rate,[10] %	41.3[c]	55.3[d]	39.0[c]	58.5[d]	—	0.07	0.93	0.68
Overall pregnancy rate, %	82.7	89.5	91.5	93.9	—	0.35	0.20	0.76
BW at pregnancy diagnosis, [11] kg	409	411	420	434	12	0.55	0.23	0.67
BCS at pregnancy diagnosis[12]	5.51	5.54	5.68	5.77	0.08	0.53	0.10	0.75

[a,b]Within a row, means without common superscripts differ at $P \leq 0.05$.
[c,d]Within a row, means without common superscripts differ at $P = 0.07$.
[1]Trt = treatment main effect; Loc = location main effect; T × L = treatment × location interaction.
[2]Supplemented daily with control supplement at 0.78% of BW.
[3]Supplemented daily with DDG supplement at 0.59% of BW.
[4]Proportion of heifers pubertal in November, immediately prior to beginning of supplementation.
[5]Proportion of heifer pubertal in mid February, when 14-d sampling intervals began.
[6]Percentage of heifers that had attained puberty prior to initial $PGF_{2\alpha}$ injection.
[7]Percentage of heifers detected in estrus within 5 d following second $PGF_{2\alpha}$ injection.
[8]Time elapsed between the second $PGF_{2\alpha}$ injection and observed standing estrus.
[9]Proportion of heifers detected in estrus that conceived to AI.
[10]Percentage of total group of heifers that conceived to AI.
[11]BW at final pregnancy diagnosis.
[12]BCS at final pregnancy diagnosis.

adequate dietary energy is supplied (Hawkins et al., 1999).

In the current study, both treatments supplied CP in excess of requirements (NRC, 2000). Heifers fed DDG were supplied excess CP in the form of UIP, whereas control heifers received excess CP in the form of DIP (Table 2). We are unable to determine if excess DIP in the control supplement decreased AI conception and pregnancy rates, rather than DDG supplementation increasing AI conception and pregnancy rates. Dairy heifers fed diets containing 21.8% CP with 82.5% of CP as degradable protein had decreased conception rate compared with heifers fed diets with 15.45% CP (73% degradable) due to decreased uterine pH 7 d after estrus (Elrod and Butler, 1993). However, uterine pH 7 d after estrus was reduced to the same extent by feeding diets with excess UIP (19.8% CP, 55.1% degradable) as excess DIP (20.4% CP, 75.4% degradable) to lactating Holstein cows (Elrod et al., 1993).

Limited research is available on effects of feeding highly degradable protein sources to beef heifers on reproductive performance. Kenny et al. (2001) increased CP intake of 18- to 24-mo-old beef heifers by fertilizing pastures with N. Forage from the pastures fertilized with high levels of N contained 23.2% CP (DM basis) and did not affect embryo survival at 30 d of gestation compared with forage (12.8% CP) from pastures fertilized with low levels of N; dietary CP was less in the current study.

Feeding diets that promote high plasma urea concentrations to beef heifers resulted in reduced embryo cleavage rates and blastocyst formation after in vitro fertilization of oocytes from small and medium follicles, but in vivo fertilization and embryonic development were not studied (Sinclair et al., 2000). Similarly, direct addition of urea to in vitro oocyte maturation media did not affect cleavage rate but decreased the proportion of cleaved oocytes that formed blastocysts at d 8 (Ocon and Hansen, 2003). In the current study, treatments were concluded 5 d after the second PGF injection, and heifers at each location were managed in a common group on pasture after AI. Heifers supplemented with DDG had similar ($P = 0.35$) overall pregnancy rates to control heifers. Weight and BCS at final pregnancy diagnosis were not affected ($P > 0.52$) by treatment.

As ethanol production in Nebraska and the Great Plains expands, greater opportunity will exist to incorporate DDG in replacement heifer diets. Dried distillers grains complement forage diets typically used for heifer development by supplying protein, energy, and P. Therefore, DDG alone may provide the majority of supplemental nutrients required in forage-based heifer development diets. In the current study, utilizing DDG as a source of protein and energy in heifer development diets to promote moderate gains did not influence age at puberty but enhanced AI conception and pregnancy rates compared with an isocaloric supplement.

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