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Effects of Dietary Inclusion of an Omega-3 Fatty Acid-based Supplement on Biological Parameters and Sperm Characteristics of Developing Beef Bulls

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Abstract

The objective was to evaluate including an omega-3 fatty acid-based supplement in the diet of growing beef bulls on biological parameters and sperm characteristics. Weaned beef bull calves (n = 39) of Angus, Hereford, or Simmental breeding were stratified by body weight and age, and then the calves were assigned to one of three dietary treatments in a completely randomized design. Treatments consisted of including an omega-3-based supplement at one of three levels to a common corn silage-based diet at 0.00 (CON), 0.48 (MOD), or 0.96 (HI) lb/head/day (dry matter basis). Managed as a common group and individually fed in precision intake management bunks, bulls (n = 13 per treatment) were supplemented for 80 days from late November 2024 to February 2025. Data were analyzed using the GLIMMIX procedures of SAS with the individual animal as the experimental unit. There was no difference ($P > 0.05$) in the percentage of morphologically normal sperm or progressive motility among treatments. A tendency for increased motility ($P = 0.10$) was observed for the HI treatment relative to CON. Day effects were observed as age increased and bulls grew for weight, average daily gain, body condition score, and scrotal circumference. Semen characteristics varied by day of collection but generally improved as bulls matured. Data suggest an omega-3 fatty acid-based supplement in the basal diet of developing beef bulls may influence semen quality under dietary levels and duration of feeding in this experiment. These findings support future work investigating omega-3 supplementation as a strategy to offset impaired semen quality associated with overfeeding and obesity-like metabolism in young bulls, as well as supplying such fatty acids in development diets that are otherwise naturally devoid.

Introduction

For seedstock bull calves being retained as future herd sires, the period between weaning and first service is critical for growth and sexual maturation. In typical Midwestern production systems, it is common for bulls to be developed postweaning on diets consisting of grass hays, silages, concentrates, and corn-processing by-products, which are naturally low in omega-3 fatty acids. Omega-3 fatty acids have been shown to have

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anti-inflammatory properties in many species. Bulls being developed at high rates of gain prior to first service may be at greater risk of experiencing metabolic stress, which can negatively impact semen quality. However, research evaluating the impact of omega-3 supplementation in modern developing bull diets on semen characteristics is generally limited. Therefore, our objectives were to evaluate the impact of including an omega-3 fatty acid-based supplement in the diet of developing beef bulls on growth and semen characteristics.

Experimental Procedures

Weaned beef bull calves (n = 39, initial body weight [BW]= 737 ± 111 lb, initial age = 282 ± 25 days) of Angus, Hereford, or Simmental breeding from the Kansas State University Purebred Beef Unit were used for this experiment. Following removal from their dams in September, bulls were fitted with electronic identification tags, adapted to a total mixed ration growing diet, and then entered the Kansas State University Precision Feed Intake facility, where they were fed in precision intake management bunks. After an adaptation period of at least 21 days, bulls were weighed on three consecutive days, with the average BW of the first two days used to assign bulls to treatments on day 0, while the average of all three days was used as initial BW. In a completely randomized design, bulls were stratified by BW and age and assigned to one of three dietary treatments: 0.00 (CON), 0.48 (MOD), or 0.96 (HI) lb/head/day (dry matter basis) of an extruded flaxseed and algae-based supplement providing omega-3 fatty acids (Better Fed Foods/NBO3, Manhattan, KS). The supplement (32.26% crude protein, 18.85% fat, 19.76% neutral detergent fiber, 11.28% acid detergent fiber, dry matter basis) was added to a corn silage-based diet, which was mixed and delivered to bulls across all treatments daily (Table 1). Corn germ meal was added along with the omega-3 based supplement to provide similar dietary crude protein levels. Bulls across all three treatments were managed as a common group and individually fed in precision intake management bunks (n = 13 per treatment) throughout the experiment. Treatments were applied for 80 days from late November 2024 to February 2025, during which the average temperature was 31°F. Ration samples were collected weekly and compiled into periods consisting of three weeks each. The composited samples were analyzed in a commercial laboratory (SDK Laboratories, Hutchinson, KS) using wet chemistry techniques for dry matter, protein, fiber components, fat, calculated energy concentration, and macro minerals.

Blood samples were collected on days -5, 53 or 55, and 80 via coccygeal venipuncture for analysis of fatty acid concentrations. Scrotal circumference (SC) was collected on day -4, 53 or 55, and day 76. Breeding soundness exams were conducted by trained personnel at the Kansas Artificial Breeding Services Unit on day 53 or 55, 76, and 101. Semen collected via electroejaculation from the breeding soundness exams was analyzed by a computer-assisted semen analysis (CASA) machine. Seminal plasma was collected immediately from an aliquot of the ejaculate by centrifugation of the ejaculate. The remaining ejaculate was placed in a water bath at 95°F for three hours as a sperm resilience stress test, and the remaining seminal plasma was collected. All seminal plasma samples were immediately frozen in liquid nitrogen and later stored in -112°F for later analysis of reaction oxygen species. Individual BW was collected on three consecutive days upon completion of the supplementation period, and weights were averaged for determination of ending BW, with a single mid-trial weight taken on day 53 or 55. Body condition score (BCS) was assessed at both trial initiation and conclusion. Thermal images of the face of the bull and both testes were taken on day -5 and 79

to evaluate thermoregulation of the testes. Carcass ultrasound was conducted by a commercial technician on day -4 and 80 for the collection of ribeye area, subcutaneous back fat between the 12th and 13th rib, and intramuscular fat.

Data were analyzed using the GLIMMIX procedure of SAS (SAS, Inc., Cary, NC) with variables collected multiple times throughout the study analyzed as repeated measures. The individual bull was considered the experimental unit. The model included the fixed effects of supplementation and day of collection with breed as a random effect. Least square means were declared significant at a *P*-value ≤ 0.05, and tendencies were declared at a *P*-value > 0.05 and ≤ 0.10.

Results and Discussion

Ingredient and nutrient composition of the base and treatment diets is presented in Table 1. Diets were formulated to have similar protein and energy across treatments, with only the fatty acid composition varying across treatments. Variables measured multiple times throughout the experiment are reported in Table 2. There was no difference ($P > 0.05$) for BW, average daily gain (ADG), or BCS among supplementation groups. Bulls increased from their initial BW of 737 lb at the start of the trial to 1,003 lb at the end. The performance data collected did not differ by supplementation group, indicating that supplementation did not influence overall growth or body condition. However, as expected, these parameters increased with the progression of the experiment. Analysis of sperm characteristics was done with a CASA machine for morphology, motility, and progressive motility of the sperm cells at day 53 or 55, 80 and 101. There were no differences for the percentage of morphologically normal sperm as influenced by omega-3 fatty acid supplementation ($P > 0.05$). There was, however, a lower percentage of morphologically normal spermatozoa in samples from the first collection compared to the collections on day 80 and 101. Interestingly, there was a tendency ($P = 0.10$) for motility to be greater for HI compared to CON bulls for all collections. Likewise, a day effect was observed for motility with sperm collected at day 101 having increased motility ($P < 0.05$) compared to day 53 or 55, and day 80, regardless of treatment. There was no supplementation effect on the progressive motility of sperm, but a day effect was observed with progressive motility increasing from day 53 or 55 to day 80. However, progressive motility decreased ($P < 0.05$) from day 80 to day 101 representing the first 21 days after omega-3 supplementation was stopped. Ribeye area, rib fat thickness, and intramuscular fat did not differ among supplementation treatments ($P > 0.05$). There was an increase in all carcass traits by the end of the trial due to gain and muscle development. Thermography of the testes, fatty acid composition of blood plasma, and reactive oxygen species in seminal plasma are currently being analyzed to help elucidate the effects that omega-3 supplementation, particularly its antioxidant properties, has on oxidative stress and ultimately sperm function in developing beef bulls.

Implications

Results suggest that omega-3 supplementation may impact sperm cell motility in young bulls within the inclusion levels and duration of this experiment, which may ultimately help counter the negative effects of overfeeding on semen quality in developing bulls.

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Table 1. Ingredient and nutrient composition of diets fed to developing bulls[1]

Ingredient, %	BASE[2]	CON[3]	MOD[3]	HI[3]
Corn silage	34.3	34.3	34.3	34.3
DDGS[4]	22.2	22.2	22.2	22.2
Dry rolled corn	20.9	20.9	20.9	20.9
Grass hay	14.7	14.7	14.7	14.7
Supplement	7.9	7.9	7.9	7.9
Nutrient, %				
Dry matter	57.40	59.73	58.58	60.53
Crude protein	12.47	13.07	12.61	13.47
Acid detergent fiber	18.79	17.87	18.08	17.81
Neutral detergent fiber	31.79	31.01	31.13	32.09
Fat	4.95	4.76	4.93	5.76
Calcium	0.92	0.87	0.80	0.76
Phosphorus	0.47	0.48	0.45	0.47
Corn germ meal[5]	---	1.98	1.29	1.19
Omega-3 supplement[5]	---	---	0.48	0.96

[1] All values on a 100% dry matter basis.
[2] Base ration fed to all treatment groups.
[3] CON = 0.00, MOD = 0.48, and HI = 0.96 lb/head/day (dry matter basis) of an extruded flaxseed and algae-based supplement providing omega-3 fatty acids (Better Fed Foods/NBO3, Manhattan, KS).
[4] Corn dried distillers grains with solubles.
[5] Amounts included on a per head per day basis.

Table 2. Effects of omega-3 supplementation and day of collection on growth, carcass characteristics, and semen parameters

	Supplementation[1]					Day[2]					
Item	**CON[3]**	**MOD[4]**	**HI[5]**	**SEM[6]**	***P*-value**	**0**	**53 or 55**	**80**	**101**	**SEM[6]**	***P*-value**
Initial body weight, lb	732	736	744	32	0.96	---	---	---	---	---	---
End body weight, lb	981	1,009	1,018	35	0.73	---	---	---	---	---	---
ADG,[7] lb	3.47	3.55	3.53	0.20	0.96	---	3.05[a]	3.99[b]	---	0.25	0.04
BCS[8]	5.5	5.5	5.5	0.13	0.86	4.69[a]	5.79[b]	6.05[b]	---	0.11	<0.01
SC,[9] in.	13.39	13.46	13.74	0.24	0.57	10.83[a]	13.96[b]	14.50[c]	14.83[d]	0.15	<0.01
Morph. normal,[10] %	56.80	68.12	70.38	6.56	0.30	---	51.05[a]	68.05[b]	76.20[b]	4.87	<0.01
Motile, %	45.50[†]	54.06	60.45[†]	4.84	0.10	---	43.57[a]	51.96[a]	64.47[b]	3.68	<0.01
Progressively motile, %	27.43	32.32	40.28	4.67	0.16	---	31.90[a]	42.56[b]	25.59[a]	3.68	<0.01
Ribeye area, square in.	4.44	4.56	4.54	0.16	0.84	3.78[a]	---	5.09[b]	---	0.09	<0.01
Ribfat,[11] in.	0.19	0.20	0.19	0.01	0.78	0.15[a]	---	0.23[b]	---	0.01	<0.01
Intramuscular fat, %	2.28	2.58	2.43	0.21	0.60	2.21[a]	---	2.65[b]	---	0.13	<0.01

[abcd] Means with unlike superscripts differ at $P \leq 0.05$.

[†] Means with like superscripts trend toward significance ($0.05 \leq P \geq 0.10$).

[1] Supplementation = mean values for all bulls across all collections.

[2] Day = mean values for all bulls across supplement levels.

[3] CON = non-supplemented.

[4] MOD = supplemented with 0.48 lb/head/day (dry matter basis) of an omega-3 based supplement (Better Fed Foods/NBO3, Manhattan, KS).

[5] HI = supplemented with 0.96 lb/head/day (dry matter basis) of an omega-3 based supplement (Better Fed Foods/NBO3, Manhattan, KS).

[6] SEM = standard error of the mean.

[7] ADG = average daily gain.

[8] BCS = body condition score.

[9] SC = scrotal circumference.

[10] Morph. normal = percentage of morphologically normal sperm.

[11] Measured between the 12th and 13th rib.