Effect of fat source and supplement delivery method on beef cow-calf performance and reproductive responses

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Summary

The effect of fat supplementation beginning thirty days before calving (Jan. 23) and continuing to the start of breeding (May 30) was evaluated using 256 beef cows ranging in age from first calf heifers to 10 year old cows. The projects first objective was to evaluate cow response to either saturated (tallow) or unsaturated (soybean oil) fat sources with respect to colostrum quality, calf survival, postpartum interval, pregnancy rate, and weaning weight. The second objective was to evaluate the effect delivery system (range cube versus slow release lick block) may have on cow and calf response.

From initiation of fat supplementation on January 23, 2002 to the start of breeding on May 30, 2002, cow body weight, body condition score and ultrasound fat depth declined across all treatments, but did not differ between treatments.

Calf calving ease score, birth weight, age at weaning, weaning weight, gain, and weight per day of age did not differ between treatments.

Colostrum was collected from a subset of cows in each treatment. Colostrum dry matter, crude protein, fat, and casein content did not differ across treatments.

Uterine ultrasound scan and fetal cranial width regression analysis were used to determine percent conception rate by breeding cycle. Combined first and second cycle pregnancy rates did not differ significantly, however, cows that received the unsaturated fatty acid source tended to have higher first and second cycle pregnancy rate.

While supplement intake by cows from the slow release lick tub was lower than predicted, cow response for the criteria measured did not differ from the other treatments.

Overall, supplementation with either fat source did not improve cow performance above that obtained with a conventional 40% protein range cube.

Introduction

Fat, because of its energy concentration and physical form, has been used as an ingredient in beef cattle supplements for many years. However, large amounts of fats do not normally occur in forages consumed by ruminants. It has been demonstrated that the addition of polyunsaturated fat, originating from plant oils, can have a positive impact on reproductive performance including ovarian follicular growth, luteal function, and pregnancy rates independent of caloric effects (Williams and Stanko, 1999).

Additions of polyunsaturated fat to the diets of cattle have favorably modified several reproductive physiological processes. Fats are categorized as being saturated (e.g., animal tallow), polyunsaturated (e.g., canola, soybean and sunflower) and highly polyunsaturated (e.g., linseed oil, fish oils) based on the number of double bonds. The use of fats in postpartum cow diets permits greater energy consumption than the ingredients they replace. When used in postpartum dairy diets, long-chain fatty acids are used with high efficiency for lactation because they are metabolized directly to milk fat (Coppock and Wilks, 1991). During lactation low density (LDL) and high density (HDL) lipoproteins undergo a unique adaptation such that pre-lactation serum lipoprotein-cholesterol concentrations of 100 - 150 mg/dL rise during peak lactation to concentrations nearing 300 mg/dL in dairy (Maynard et al., 1931; Noble, 1978) and beef cattle (Williams, 1989). Puppione (1978) reported the observed rise in lipoprotein concentration may be a consequence of mammary gland activity and the hepatic production of triglycerides for synthesis of milk fat. Coincidentally, fat supplementation stimulates synthesis and accumulation of lipoprotein-cholesterol and cholesterol esters in tissues, body fluids and the ovary (Williams, 1999). Circulating lipoproteins in ruminants are predominantly of the HDL type and are the only lipoprotein with access to the intrafollicular compartment (Caravaglios and Cilotti, 1957). Previous research at North Dakota State University has evaluated the concept that dietary-mediated increases in plasma cholesterol could modulate luteal function (Talavera et al., 1985). Dairy heifers receiving full-fat supplemention of whole sunflowers (15% of diet) experienced a dramatic increase in serum cholesterol concentration and mid- to late-luteal phase concentrations of progesterone were also elevated (Talavera et al., 1985). Fats derived from plant oils have yielded the most positive responses due mainly to the prevalence of linoleic acid. Polyunsaturated fats, compared to saturated and highly polyunsaturated fats, appear to be the most effective with respect to the onset of follicular activity. Thomas et al. (1997) demonstrated that polyunsaturated soybean oil increased the number of medium-sized follicles relative to other fat sources within 20 days after initiation of fat feeding. Increased liver gluconeogenesis, subsequent insulin rise and proliferation of granulosa cells resulting from enhanced production of propionate in the rumen when soybean oil is present (linoleic) is thought to be one possible explanation for the increase in follicular activity (Thomas et al., 1997).

In research conducted in eastern Montana, supplemental fat from crushed safflower seed was fed precalving to first calf heifers to evaluate the effect of cold tolerance on newborn calves, which is believed to increase the presence of "brown fat" in the new born calf, tended to improve calf survival and increased reproductive performance (Bellows et al., 2000). A second study with first calf heifers fed soybean, safflower, and sunflower seeds precalving resulted in a 14% increase in pregnancy rate (Bellows et al., 2001). Fat supplementation to mature cows was also studied. Mature 3 to 8 year old cows receiving fat supplementation delivered in free choice lick tubs or compressed blocks during late gestation were evaluated. Effect of delivery system and fat on dam precalving weights, condition score, calf birth weight, and calving ease did not differ. Cyclicity at begin breeding and final pregnancy were affected by a calving season x delivery group interaction, such that, cows calving in February followed by limited postpartum forage benefitted from fat supplementation whereas cows calving in April did not. Precalving fat increased weaning weight (Bellows et al., 2000). In a third investigation, Grings et al. (2001) in a 2 year study evaluated prepartum high (safflower seed and meal) and low (safflower meal and barley) fat supplementation effects on cow performance pre- and postpartum. Each year, 3 year old and 5-7 year old cows from February, April and May calving seasons were assigned to supplement types. Effects of supplement type were limited and only found in interactions. Three year old cows calving in February and 5-7 year old cows calving in April receiving high fat had greater pregnancy rates than cows fed low fat; the opposite was true for 3 year old cows calving in April. There was no effect of supplement type on cows calving in June. Varying conditions associated with season of calving affected cow performance and response to supplementation.

It is still unclear, however, under applied field conditions as to whether the source of fatty acids (tallow vs vegetable oil) in the fat is important in determining cow and calf response to oilseed supplementation. Secondly, delivery method under field conditions needs further investigation to determine whether cow response differs between either hand-fed supplements or self-fed low-moisture cooked molasses products.

Objectives

1. Determine whether or not beef cows respond differently when supplemented with either saturated or unsaturated fat with respect to colostrum quality, calf survival, post partum interval, pregnancy rate, and weaning weight.

2. Determine if cow response differs between either hand-fed supplements or self-fed low-moisture cooked molasses products.

Materials and Methods

Two hundred fifty-six beef cows and heifers ranging in age from 2 to 10 years of age were randomized in a complete-block design based on cow age, weight and estimated calving date. Blocks consisted of first calf heifers, 2nd - 4th calf cows, 5th - 7th calf cows, and 8th calf cows and older. Sixteen (16) beef cows are allotted to each pen, which served as the experimental unit. Individual cow served as the experimental unit for reproductive measurements.

Treatments:

1. Control - 40% CP protein range cube, hand-fed at 1 lb/hd/day

2. Saturated fat (tallow) - 20% CP range cube with 10% added fat, hand-fed at 2 lb/hd/day.

3. Unsaturated fat (soybean oil) - 20% range cube with 10% added fat, hand-fed at 2 lb/hd/day.

4. Unsaturated fat (soybean oil) 35% CP free-choice lick tub with 20% added fat, expected consumption of 1 lb/hd/day.

Supplement feeding began 30 days before calving, which was January 23, and continued until the start of the breeding season on May 30.

Calculated analysis of the experimental supplements is shown in Table 1, and was provided by Cooperative Research Farms. Our laboratory analysis of the supplements delivered (Table 2) agrees with the calculated analysis for those criteria that are similar.

Cows in the study were fed an alfalfa-bromegrass hay that averaged 10.9% CP before calving and hay that was largely alfalfa after calving, averaging 14.8% CP. In addition to the experimental supplements and alfalfa-bromegrass hay that was fed daily, cows were fed supplemental corn grain after calving from April 19 to May 30. Corn was provided such that total dietary energy was comparable across treatments. Initially, treatments assigned to receive 2 pounds of experimental supplement were given 2 pounds of corn and those fed 1 pound of experimental supplement were given 3 pounds of corn. We observed that the cows were lactating heavier than anticipated and were losing more weight than desired in early May and, therefore, increased hay and corn deliveries on May 12 and again on May 15. Hay and corn delivery changes and the amount delivered is shown in Table 4.

Cows in the investigation were bred naturally using fertility tested bulls. Ultrasound scans and fetal cranial regression analysis were used to determine breeding cycle pregnancy rate.

Measurements taken included:

1. *Animal Weights* - Cows were weighed initially when supplementation was initiated, after calving, and at the start of the breeding season. Calves were weighed at birth and at weaning.

2. *Cow Condition and Fat Depth* - Visual condition score coincided with each fat depth ultrasound scan. Ultrasound fat depth scans were taken at the beginning of the study, as each cow calved, and at the beginning of breeding. Body condition score (BCS) was taken visually (1-9 System) and real-time ultrasound fat depth measurements were taken at a rib location 3 inches off the midline between the 12th and 13th ribs. A rump measurement was also taken on a line between the hoop and pin bones.

3. *Colostrum Evaluation* - Two heifers and two cows from each treatment were selected for colostrum analysis and evaluation. Samples were collected within 12 hours of calving from one unnursed quarter, frozen and analyzed for dry matter, crude protein, fat, and casein content.

4. *Forage Analysis* - Hay fed to cows in each treatment was pre-evaluated by core sampling. Samples were composited at the end of each week for proximate analysis.

5. *Effect of Supplementation* - Effect of supplementation was correlated to calf survival, post partum interval and reproductive efficiency (pregnancy rate corresponding to the 1st and 2nd cycles and at weaning determined using ultrasonography), cow condition score change, fat depth change, and calf weaning weight.

6. *Health and Death Loss* - Health and Death Loss records were kept on an individual cow and calf basis.

Statistical Analysis:
Data will be analyzed as a complete-block design using statistical analysis procedures of SAS (1996).

Results and Discussion

This fat supplementation study was designed to determine differences in cow performance following supplementation with either saturated or unsaturated fat delivered either via a range cube or molasses lick tub. Supplement calculated nutrient analysis is shown in Table 1. Supplement and forage laboratory analysis using wet chemistry are shown in Tables 2 and 3. Additional energy from corn grain was fed after calving. A schedule of hay and corn grain changes during the trial is shown in Table 4. Hay, experimental supplement, corn grain, and mineral fed during the experiment is summarized in Table 5.

Cow weight change during the 127 day period (Jan 23 to May 30, 2002) encompassed in this experiment was negative for all test supplements at the start of the breeding season (Table 6), but the observed differences were not significant. With change, as expected, was greatest after calving. As percent of the total loss, wight loss form precalving to postcalving was 57.2, 72.3, 72.9 and 78.0% for the C-Pro, SAT, USAT and U-TUB, respectively. The remainder of weight loss between calving and the start of the breeding season was correspondingly less with the exception of the control which was nearly the same after calving and t the start of the breeding season. Cow weight across treatments, at the start of the breeding season, did not differ although cows receiving an unsaturated far source (soybean oil) were slightly heavier. Test supplements were delivered according to protocol and, as shown in Table 5, consumption was .975, 1.92, and 1.96lb/head/day, for C-Pro, SAT, USAT fat sources delivered in the range cube form. Intake for the unsaturated fat delivered in the cooked molasses tub was .623 lb/head/day, which was .377 lb. Less than the desired intake of 1.0 lb/head/day. Our research team does not have an explanation for the reduced intake. We anticipated tub consumption would increase after calving, however, consumption was virtually the same.

Body condition declined linearly form precalving to breeding among all treatments (Table 7). Prebeeding fat depth did not differ, however, cows receiving unsaturated fat bearing supplements tended to have greater fat depth at the start of the breeding season on May 30th.

Colostrum analysis for percent dry matter, crude protein, fat, and casein did not differ between treatments and is shown in Table 8.

With respect to calving, age of calf, calf birth weight, calving ease score, weaning weight, gain and calf weight/day of age are shown in Table 9. None of the criteria measured differed significantly.

Uterine ultrasound scan and fetal cranial width regression analysis were used to determine percent conception rate by breeding cycle (Table 10). Statistical differences were not measured between test supplements, however, cows receiving the USAT test supplement delivered either in a range cube or cooked molasses tub tended to demonstrate greater first cycle pregnancy rate. Combined first and second cycle conception rates were 88.1, 88.9, 95.9, and 87.8% for C-Pro, SAT, USAT, and U-TUB, respectively, tended to favor unsaturated soybean oil. On average, and compared to the other treatments, supplementing with unsaturated soybean oil resulted in 7.6% greater combined first and second cycle pregnancies, but the difference was not significant. Although gain form birth to weaning did not differ, calves from cows wintered with an unsaturated fat source weaned 13.2 lbs. more beef per cow. When reps were combined, unsaturated fat supplemented cows weaned 845 pounds more weaning weight.

Overall, supplementation with either fat source did not improve cow performance above that obtained with a conventional 40% protein range cube.
While this project failed to show an advantage for the use of supplemental linolenic fatty acid (soybean oil) future research is planned with a more refined experimental design designed to address the effect of fat supplementation only.

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Table 1. Calculated supplement analysis (as-fed basis).

	CRF 170-1 Control Prot.	CRF 170-2 Sat. Fat	CRF 170-3 Unsaturated Fat	CRF 170-4 Unsaturated/Tub
CP, %	39.99	20.01	20.00	35.01
UIP, %	13.59	5.56	5.59	8.77
Crude Fat, %	2.22	10.10	10.00	19.98
Crude Fiber, %	5.50	9.50	8.24	.91
TDN, %	69.33	78.19	78.70	93.36
Nem, Mcal/lb.	.75	.86	.87	.97
Neg, Ncal/lb.	.49	.55	.55	.59
Calcium, %	2.01	.99	1.00	3.12
Phosphorus, %	1.00	.60	.60	.99
Magnesium %	.35	.33	.33	.24
Postassium, %	1.57	1.01	.97	3.18
Sulfur, %	.38	.20	.20	.15
Sodium, %	1.33	.75	.75	1.05
Dry Matter, %	89.62	89.79	89.55	95.78
Vit. A (Added), IU/lb.	40,003	19,832	19,832	59,964
Vit. D (Added), IU/lb.	8,000	4,000	4,000	10,000
Vit E (Added), IU/lb.	32	16	16	50
Zinc, ppm	728	410	409	457
Manganese, ppm	680	391	391	408
Iron, ppm	205	142	133	223
Copper, ppm	227	123	122	145
Iodine, ppm	14.00	7.35	7.35	16.54
Cobalt, ppm	2.40	1.38	1.38	1.82
Selenium, ppm	4.15	2.28	2.28	3.11
Selenium (Added), ppm	4.00	2.00	2.00	3.00

Table 2. Supplement laboratory analysis (DM Basis).

	DM, %	ASH,%	CP, %	ADF,%	NDF,%	IVDMD,%	IVOMD,%
Control 170-1	89.2	16.8	42.9	9.57	19.2	89.1	84.3
Sat. Fat 170-2	88.05	11.0	22.7	11.8	30.97	72.7	65.9
Unsat Fat 170-3	89.5	10.5	22.7	12.8	32.33	73.9	67.5
Unsat Tub 170-4	93.3	16.1	38.8	.7	0	96.2	91.9
Dry Rolled Corn	89.0	1.32	8.8	1.8	7.8	96.25	92.6

Table 3. Analysis of forage fed.

	DM,%	ASH,%	CP, %	ADF,%	NDF,%	IVDMD,%	IVOMD,%
1/30/2002	98.13	7.55	11.18	37.56	59.34	58.57	58.08
1/28/2002	96.70	9.23	10.80	33.34	58.01	55.95	54.62
1/30/2002	96.66	9.00	10.28	35.05	59.73	55.43	55.37
2/1/2002	96.90	8.38	10.01	34.28	59.85	56.79	55.71
2/10/2002	94.90	7.76	9.60	34.46	58.99	55.15	54.87
2/10/2002	96.03	8.80	9.09	34.21	60.13	54.98	55.27
2/3/2002	97.17	8.57	11.97	33.91	54.20	57.51	56.87
2/7/2002	97.06	8.19	11.53	34.92	56.33	58.13	57.68
2/17/2002	97.20	8.73	11.03	33.73	56.48	62.31	57.21
2/17/2002	97.24	8.64	9.61	36.27	62.60	54.36	54.24
2/17/2002	96.71	8.74	12.01	33.02	52.67	59.52	58.57
2/17/2002	96.99	9.04	12.16	33.77	52.34	61.59	61.16
Calving:							
3/10/2002	96.87	8.40	9.65	35.18	58.90	59.16	57.46
3/17/2002	97.26	8.02	10.78	33.64	57.02	60.70	60.03
3/24/2002	97.21	9.88	16.15	35.16	48.56	61.34	59.45
3/31/2002	97.22	10.41	19.25	30.98	42.10	64.20	63.26
4/14/2002	97.81	9.49	16.05	36.27	49.06	58.23	57.16
4/14/2002	97.64	9.58	16.92	33.29	45.31	63.88	62.96

Table 4. Hay and corn delivery changes per head per day.

	Hay	Corn*		Hay	Corn*
Jan. 23 - April 19			**May 8 - May 14**		
Heifers	25.7	--	Heifers	23.0	4 or 5
3-4	27.4	--	3-4	26.0	4 or 5
5-6-7	29.1	--	5-6-7	26.5	4 or 5
8-9-10	29.2	--	8-9-10	27.5	4 or 5
April 19 - May 7			**May 15 - May 30**		
Heifers	22.0	2 or 3	Heifers	27.5	4.8 or 6
3-4	25.0	2 or 3	3-4	31.2	4.8 or 6
5-6-7	25.5	2 or 3	5-6-7	31.8	4.8 or 6
8-9-10	26.5	2 or 3	8-9-10	33.0	4.8 or 6

* One pound less corn was fed to the groups receiving 2 pounds of experimental supplement.

Table 5. Feed intake.

	Control	Saturated Fat	Unsaturated Fat	Unsaturated Fat/Tub	P-Value
No. Cows	64	64	64	64	
Total Feed Intake, lb.	248472.8	247020.2	251806.4	242930.6	.96
Hay, lb.	227416.2	221430.8	225891.1	225205.1	
Expt'l Suppl. Intake, lb.	7944	15648	15968	5073	
Corn, lb.	13101.1	9930.0	9935.9	12641	
Mineral, lb.	11.5	11.4	11.4	11.5	
Feed/Cow, lb.	3882.4	3859.7	3934.5	3795.8	.96
Feed/Cow/Day, lb.	30.51	30.33	30.92	29.83	
Expt'l. Suppl./Cow, lb.	124.13	244.5	249.5	79.27	
Expt'l. Suppl./Cow/Da., lb.	0.975	1.921	1.961	0.623	
Corn/cow/da., lb.	4.99	3.78	3.79	4.82	.13

Table 6. Cow weight change precalving to breeding May 30, 2002.

	Control	Saturated Fat	Unsaturated Fat	Unsaturated Fat/Tub	P-Value
MPPA Value	100.3	99.6	100.0	100.1	.98
Da. on Test	127.25	127.25	127.25	127.25	
Cows Age, yrs.	5.21	5.28	5.30	5.28	1.0
Precalving Cow Wt., lbs.	1326.0	1336.0	1344.0	1415.0	.63
Post Calving Wt., lbs.	1235.0	1224.0	1242.0	1213.0	.99
Breeding Wt., lbs.	1167.0	1181.0	1204.0	1156.0	.85
Cow Wt. Change, lbs.	-159	-155	-140	-259	.54
ADG, lbs.	-1.25	-1.22	-1.07	-2.03	.54

Table 7. Body condition measurements.

	Control	Saturated Fat	Unsaturated Fat	Unsaturated Fat/Tub	P-Value
BCS (visual):					
Start (Jan 23)	5.7	5.7	5.7	5.9	.80
Postcalving	5.1	5.3	5.3	5.2	.95
End (May 30)	4.3	4.4	5.0	4.4	.15
Fat Depth (ultrasound):					
Rib:					
Start (Jan 23)	.44	.42	.49	.49	.85
Postcalving	.33	.31	.35	.35	.95
End (May 30)	.25	.24	.27	.27	.59
Rump:					
Start (Jan 23)	.68	.61	.73	.72	.89
Postcalving	.48	.43	.55	.52	.89
End (May 30)	.27	.27	.34	.29	.43

Table 8. Colostrum analysis.

	Control	Saturated Fat	Unsaturated Fat	Unsaturated Fat/Tub	P-Value
Dry Matter, %	21.47	20.47	19.84	20.21	.95
Crude Protein, %	20.61	20.08	18.37	20.84	.94
Fat, %	4.91	5.97	4.60	5.67	.90
Casein, %	5.51	5.97	5.10	6.28	.93

Table 9. Calf birth and weaning weight comparison.

	Control	Saturated Fat	Unsaturated Fat	Unsaturated Fat/Tub	P-Value
Calf Weaning Age, Days	204.0	206.0	210.0	206.0	.99
Calf Birth Wt., lbs.	90.7	90.7	89.4	88.8	.99
Calf Wn. Wt., lbs.	501.7	503.9	514.1	481.9	.91
Calf Ga., lbs.	411.5	413.2	424.7	393.0	.90
Weight/Day of Age	2.02	2.01	2.02	1.91	.88
Calving Ease Score *	1.02	1.03	1.02	1.06	.78

* 1=Unassisted, 2=Light Pull, 3=Hard Pull, 4=C-Section, 5=Born Dead

Table 10. Percent of conception rate by cycle (21da).

	Control	Saturated Fat	Unsaturated Fat	Unsaturated Fat/Tub	P-Value
Pregnancy Rate: *					
21 da, %	45.76	48.15	58.43	56.36	.48
42 da, %	42.37	40.74	37.50	30.91	.48
63 da, %	11.86	11.11	3.57	12.73	.48
Overall, %	92.2	87.5	90.6	90.2	.89