Fat research papers – ADSA conference summary 2023

Richard Kirkland

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Fatty acids and dairy products

2313

Effects of dietary lipid supplements on milk production and raw quality in dairy cows.

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This study was conducted to evaluate the effects of 4 lipid supplements on milk production and technological properties. Ten multiparous Holstein cows (64 ± 21 DIM) were used in a replicated 5 × 5 Latin square design and fed a basal TMR without supplementation (CTL) or with 2% (DM basis) fatty acids (FA) provided as soybean oil (SO), calcium salts of palm FA (CS), hydrogenated tallow FA (HT) or palmitic acid-enriched supplement (PA). Periods lasted 21 d, with the last 5 d used for milk sampling and production measurements. Data were analyzed using the MIXED procedure of SAS, with cow as random effect. Intake of DM was similar between treatments (29.5 ± 0.6 kg/d; P = 0.14). Milk yield was increased with SO compared with CTL, whereas CS and PA tended to increase milk yield compared with CTL (Table 1). Milk fat content was decreased with SO compared with any other treatment and increased with PA compared with CS. Milk true protein content was greater for PA and CTL compared with CS or SO, but true protein yield was not affected. Energy-corrected milk (ECM) and fat yield were increased by PA compared with CTL or SO. Milk urea nitrogen (MUN) was lower with SO compared with any other treatment and was also lower for CS compared with PA. Fat globule diameter (D4,3) tended to be greater for PA than SO. Casein micelle size and milk lipolysis (increase in milk free FA content after 24h of storage at 4°C) was not affected by treatment. Overall, HT had limited impact on milk composition, while CS and SO decreased milk protein content and PA increased ECM compared with the CTL diet.

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Effects of dietary lipid supplements on milk production and raw quality in dairy cows.

Table 1 (Abstr. 2313).

	Treatment[1]						
	CTL	PA	HT	CS	SO	SEM	*P*-value
Milk yield, kg/d	42.1^{b}	44.1^{ab}	44.0^{ab}	44.2^{ab}	45.4^{a}	1.3	<0.01
ECM, kg/d	42.9^{b}	46.3^{a}	45.5^{ab}	44.3^{ab}	43.1^{b}	1.5	0.01
Fat, %	4.08^{ab}	4.31^{a}	4.22^{ab}	4.01^{b}	3.58^{c}	0.16	<0.01
Fat, kg/d	1.70^{bc}	1.89^{a}	1.84^{ab}	1.76^{abc}	1.61^{c}	0.08	<0.01
True protein, %	3.32^{a}	3.33^{a}	3.27^{ab}	3.19^{b}	3.19^{b}	0.08	<0.01
True protein, kg/d	1.39	1.46	1.43	1.41	1.44	0.05	0.16
MUN, mg/dL	13.1^{ab}	13.6^{a}	12.5^{ab}	11.9^{b}	9.7^{c}	0.6	<0.01
$D_{4,3}$, µm	4.04^{xy}	4.12^{x}	4.07^{xy}	4.05^{xy}	3.79^{y}	0.11	0.09
Casein micelle size, nm	161	166	161	163	163	4	0.48
Lipolysis, mEq/100g fat	0.48	0.63	0.48	0.62	0.50	0.08	0.23

- Rumen-unprotected soya oil increased milk yield but slashed milk fat by 0.5%
- High-C16 supplement produced highest numerical milk fat %

[1]Means within a row with different superscripts differ at $P \leq 0.05$ (a,b,c) or $0.05 < P \leq 0.10$ (x,y)

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Table 1 (Abstr. 2313).

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The short-term effect of increasing doses of palmitic and stearic acid on milk fat production in Holstein cows.

A. N. Staffin*, K. J. Harvatine. Penn State University University Park, PA.

Fat supplements high in palmitic and stearic acid are commonly fed to dairy cows but there is limited data directly comparing these fatty acids (FA) at different dose levels. The objective was to compare the short-term effect of feeding palmitic and stearic acid at increasing doses on milk fat production. The hypothesis was that cows supplemented with palmitic acid would have a greater increase in milk fat yield at lower doses compared with stearic acid and that both FA would reach a plateau within the doses tested. Twelve second lactation Holstein cows (106 ± 31 DIM) were arranged in a replicated 3x3 Latin square design with a dose escalation design within period and a ≥ 10 d washout between periods. Treatments included a no-supplement control (CON), a FA supplement high in palmitic acid (PA; > 80% palmitic) and a FA supplement high in stearic acid (SA; 80% stearic and 10% oleic). The FA supplements were fed at increasing doses every 4 d targeting 0g, 150g, 300g, 500g, and 750g/d. Milk samples were taken on d 3 and 4 of each dose and were composited within dose level according to milk yield. Data were first analyzed by ANOVA with preplanned contrasts testing CON vs PA, CON vs SA, and PA vs SA at each dose level and second by random regression. Both analyses included the random effects of cow and period and the fixed effects of treatment, dose, and their interaction. PA progressively increased milk fat yield and concentration compared with CON and was higher than control at 500g of supplementation ($P = 0.03$, +132g/d for yield and $P = 0.003$, +0.37% for concentration) and greater. Stearic acid increased milk fat yield compared with CON only at 750g ($P = 0.03$, +138g/d). Neither PA nor SA modified milk yield compared with CON or each other and milk fat yield also did not differ between PA and SA. By regression analysis, there was a treatment by dose interaction for both milk fat yield ($P = 0.008$) and concentration ($P < 0.001$) where PA increased at a faster rate than SA or CON. In conclusion, PA increased milk fat yield over CON at lower doses compared with SA, but neither FA treatment reached a maximal response with the doses tested.

- Milk fat % increased progressively with increasing doses of C16 from 150, 300, 500 and 750 g/d; +0.37% at 500 g/d

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Effects of increasing dietary palmitic acid inclusion on production by lactating Holstein cows.

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The optimal dietary inclusion rates of palmitic acid (C16:0) and stearic acid (C18:0) when oleic acid (C18:1) is held constant are unknown. Lactating Holstein cows (n = 20; 117 ± 21 DIM) were assigned to 1 of 5 treatments in a replicated 5 × 5 Latin square design balanced for carryover effects. Treatments were a basal diet with no added fat (CON), or the basal diet supplemented with 2% (DM) fatty acid supplements containing 9% C18:1 and 35% C16 (PA35), 50% C16 (PA50), 65% C16 (PA65), or 80% C16 (PA80), with the remainder being mostly C18:0. Each treatment period lasted 21 d with an adaptation phase (d 1 to 14) and a measurement phase (d 15 to 21). Cows were milked 2 times daily at 0400 and 1600 h with milk weights recorded for each milking. Milk samples were collected at each milking on d 20 and 21 of each treatment period and composited by day. Data were analyzed using the MIXED procedure of SAS. Contrasts were CON vs fat supplementation and the linear, quadratic, and cubic effects of increasing C16:0. Significance was $P < 0.05$, trends were $P < 0.10$. As the C16 inclusion rate increased, PA65 produced the largest milk yield (37.9 ± 1.08 kg/d), although the quadratic effect did not reach significance ($P = 0.108$). The FCM increased linearly ($P = 0.004$) as palmitic acid increased. Fat yield increased linearly ($P < 0.01$); PA50 and PA65 had the greatest fat yield compared with CON (1.59 each vs 1.40 ± 0.74 kg/d; $P < 0.01$). Fat percentage increased linearly ($P < 0.01$), with PA65 having the largest fat percent compared with CON (4.34 vs 3.95 ± 0.14%; P = < 0.01). No differences were observed for DMI ($P = 0.75$). Increasing palmitic acid inclusion rates in fat supplements for Holstein cows improved milk yield, fat content, fat percentage, and FCM with no effects on DMI. The optimal short-term supplemental inclusion rate for C16:0 was between 50 and 65%, with 9% C18:1 and the remainder C18:0. Further research is needed to determine the long-term effects on DMI, production, body condition, health, and reproduction.

- Largest response in milk fat achieved with supplement containing 65% C16

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Effect of palmitic acid supplementation and a milk fat depressing diet on milk production, fatty acid profile, and polar metabolites.

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Milk fat yield can be decreased by diet-induced milk fat depression (MFD) and increased by dietary palmitic acid (PA) supplementation. Production responses to these diets are well characterized, but little is known of their effect on minor metabolites in milk. The objective of this study was to characterize the effect of MFD and PA supplementation on milk production, fatty acid (FA) profile, and polar metabolites. Twelve Holstein cows were used in a 3 × 3 Latin square design with 21-d experimental periods. Treatments were a control diet (17% CP, 32% NDF, and 27% starch), a high PA supplement at ≈2% DM of the control diet (88% PA), and a diet to induce MFD (17% CP, 26.5% NDF, 33.5% starch, and 2.2% soybean oil). Data were analyzed with a mixed model with the fixed effect of treatment and random effect of cow and period, and means were separated using a protected LSD. There was an effect of treatment on dry matter intake ($P < 0.001$), where MFD increased intake by 3.0 kg/d compared with control, and PA diet did not differ from control. There was no effect of treatment on milk yield ($P = 0.53$). Milk fat concentration and yield increased by 0.30 percentage units and 160 g/d with the PA supplement, and MFD decreased milk fat by 1.35 percentage units and 520 g/d ($P < 0.001$). The MFD diet decreased the concentration of milk FA <16 C and 16 C FA by 41 and 20% and increased the concentration of > 16 C FA by 40% compared with control ($P < 0.001$). The PA supplement increased the concentration of milk 16 C FA by 40% and decreased <16 C FA by 16% compared with control ($P < 0.001$). The MFD diet altered the concentration of citric acid cycle (TCA) intermediary metabolites in milk, a significant source of NADPH for de novo lipogenesis; interestingly, citrate increased by 57% and succinate and α-ketoglutarate decreased by 27% and 66%, respectively, compared with control ($P < 0.001$). In contrast, the PA supplement had no effect on any TCA intermediary metabolites. The PA supplement and MFD resulted in the expected changes in milk fat yield and FA profile and modified milk polar metabolites that may reflect the changes in lipogenic pathways.

- C16 supplementation @2% of diet DM increased milk fat by 0.3%

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1199M

Effect of seasonality on production responses and milk fatty acid profile of lactating dairy cows when C16:0-enriched supplements are included in diets: A meta-analysis.

M. A. Karpyn Esqueda*, J. M. dos Santos Neto, A. L. Lock. Michigan State University East Lansing, MI.

We performed a meta-analysis to evaluate the effects of seasonality on milk production responses and milk fatty acid (FA) profile of dairy cows fed non-FA-supplemented control diets (CON) compared with diets supplemented with C16:0-enriched supplements (PA). The data set included 366 individual observations from multiparous Holstein cows averaging 187 ± 51 DIM from 8 studies across 4 seasons (spring = 147; summer = 122; fall = 47; winter = 50). Treatments were: CON, n = 180; and PA, n = 186. The C16:0-enriched supplements were included at 1.45 ± 0.08% diet DM. On average, across the seasons, CON diets contained (%DM mean ± SD) 30.9 ± 2.27 NDF, 20.1 ± 2.14 forage NDF, 27.5 ± 1.73 starch, 16.7 ± 0.62 CP, and 2.8 ± 0.42 FA. The PA diets contained (%DM) 30.2 ± 2.23 NDF, 20.1 ± 2.16 forage NDF, 27.5 ± 1.77 starch, 16.6 ± 0.61 CP, and 4.74 ± 0.31 FA. The statistical analyses included the fixed effects of treatment, season, and the interaction between treatment and season, and the random effects of study and cow nested within study and period. Period refers to periods from change-over designs and time points from continuous designs. Our model also used DIM and previous lactation 305-d mature-equivalent yield as covariates. Overall, compared with CON, PA increased the yields of milk (1.18 kg/d), fat (0.08 kg/d), FCM (1.82 kg/d), and ECM (1.47 kg/d), and milk fat content (0.10%; all $P < 0.01$). We observed interactions between season and treatment for the yields of milk, fat, FCM, and ECM ($P \leq 0.07$). Compared with CON, during spring and summer PA improved the yields of milk (0.99 and 3.02 kg/d), FCM (1.54 and 3.63 kg/d), and ECM (1.24 and 3.17 kg/d; all $P < 0.01$), respectively. Moreover, feeding PA tended to increase FCM during fall 1.05 kg/d and winter 1.07 kg/d ($P \leq 0.07$). Compared with CON, PA increased fat yield across all seasons ($P < 0.01$) with varying magnitudes (spring 0.07, summer 0.13, fall 0.08, and winter 0.06 kg/d). In conclusion, feeding C16:0-enriched supplements improved production response of lactating dairy cows throughout the year but responses were better during warmer seasons of the year.

1197M

Effect of palmitic and stearic acids on plasma ceramide concentrations in lactating dairy cows.

S. L. Burtnett*, K. J. Harvatine. Pennsylvania State University State College, PA.

Ceramides are bioactive lipids and some are associated with insulin resistance and have been reported to increase with palmitic acid supplementation. Our objective was to investigate the effect of palmitic (PA) and stearic acid (SA) on plasma ceramide profile. We hypothesized that total ceramide concentrations and long-chain ceramides would be influenced by PA more than SA supplementation. Blood samples from a previous study stored at −80C were used for the project. The study used 12 multiparous cows in a 4 × 4 Latin square design. Treatments were 1) control with no supplemental fat (CON), 2) high PA (HP; 91% C16:0), 3) high SA (HS; 92.5% C18:0), and 4) PA and SA blend (MIX; 45.3% C16:0 and 49.1% C18:0). Fatty acid supplements were fed at 1.95% of DM intake. Plasma samples were analyzed for ceramide concentrations via LC-MS/MS. Data were analyzed using the MIXED procedure of SAS. The model included the random effects of cow and period and the fixed effect of treatment. A total of 14 different ceramides were identified. The predominant ceramides for all treatments were C16:0 and C24:0 (averaging 36.1% and 34.2% respectively), in agreement with previous work from other labs. Total ceramide concentration increased with increasing PA supplementation; ceramide was highest ($P < 0.01$) in HP (601.5 ng/mL) followed by MIX (456.7 ng/mL) compared with HS and CON (399.3 and 382.1 ng/mL), which were not different from each other. A similar pattern occurred in C16:0 ceramide concentration. The C24:0 ceramide was also highest ($P < 0.01$) in HP (240.0 ng/mL) and MIX (174.4 ng/mL) versus CON (146.2 ng/mL) while HS (152.0 ng/mL) tended to be greater than CON ($P = 0.08$). In conclusion, ceramide concentration increased with PA supplementation while high SA supplementation did not increase ceramides. Differences in nutrient partitioning, milk fat yield, and body weight gain with PA supplementation may be through changes in ceramide signaling.

Oleic acid (C18:1)

2666

Oleic acid promotes lipid accumulation and improves mitochondrial function in bovine adipocytes.

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In rodent models, oleic acid (OA) enhances mitochondrial biogenesis and function. In periparturient cows, OA limits lipolysis and improves adipose tissue (AT) insulin sensitivity. However, the mechanisms behind OA effect in cows are still unknown. The objective of this study was to determine the effect of OA on lipogenesis and mitochondrial function in bovine adipocytes. Pre-adipocytes were isolated from subcutaneous AT explants (n = 9, nonlactating, non-gestating dairy cows) and induced to differentiate. Mature adipocytes were cultured with standard differentiation media (CON) supplemented with palmitic acid (PA)or OA at 100, 200, and 300 µM, or mixed PA:OA at 60:40, 50:50, and 40:60 ratios at 300 µM for 7 d. All fatty acids (FA) were solubilized in albumin (10% BSA). Intracellular lipid droplets were quantified using Adipored assay (RFU/ng DNA). Expression of lipogenic and mitochondrial gene networks was evaluated using RT-qPCR. Protein was quantified by capillary electrophoresis. The statistical model included the random effect of cow and fixed effect of treatment. Compared with CON, the 300PA, 200OA, 300OA, 60:40, 50:50, and 40:60 treatments enhanced lipid accumulation ($P < 0.01$). 300OA and 40:60 stimulated lipid uptake and adipogenesis through increasing the expression of PPARγ compared with all other treatments ($P < 0.01$). The 300OA and 60:40 treatments tended to increase expression of PPARα compared with 40:60 ($P = 0.06$). Moreover, compared with 300PA, 300OA and 40:60 tended to increase expression of insulin-regulated glucose transporter GLUT4 ($P = 0.06$). Compared with CON and 200PA, 300OA and 50:50 tended to increase lipid droplet associated protein PLIN5 content ($P = 0.10$). Within the mitochondria, 300PA tended to decrease the expression of FA transport protein system (CAC, CPT1, CPT2), complex I protein (NDUFS1), SIRT1, and PGC1α ($0.05 \leq P \leq 0.07$) compared with CON, 300OA and 40:60 treatments. This shows that OA, in combination with PA, restores mitochondrial biogenesis and improves oxidative phosphorylation. Our results provide mechanistic evidence for the use of OA in dairy cow diets during the periparturient period to enhance lipid accumulation.

- Further evidence that supplying C18:1 in rumen-protected form to benefit cows in early lactation

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Increasing dietary inclusion of high oleic acid soybeans increases milk production of high-producing dairy cows.

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We determined the effect of increasing dietary inclusion of roasted and ground high oleic acid soybeans (HOSB) on production responses of high-producing dairy cows. Conventional soybeans contain ~15% oleic acid and ~50% linoleic acid whereas HOSB contain ~75% oleic acid and ~7% linoleic acid. Twenty-four multiparous Holstein cows (50.7 ± 4.45 kg/d of milk; 122 ± 57 DIM) were randomly assigned to treatment sequences in a replicated 4x4 Latin square design with 21-d periods. Treatments were increasing doses of HOSB at 0, 8, 16, and 24% DM. HOSB replaced conventional soybean meal and hulls to maintain diet nutrient composition (%DM) of 28.0% NDF, 21.3% forage NDF, 27.3% starch, and 17.8% CP. Ether extract of each treatment was formulated to contain 3.25, 4.52, 5.80, and 7.08%DM, respectively. The statistical model included the random effects of period and cow within square and the fixed effect of treatment. Pre-planned contrasts included the linear (L), quadratic (Q), and cubic (C) effects of increasing HOSB. Results in the text are presented in the following order: 0%, 8%, 16%, and 24% HOSB. Increasing dietary inclusion of HOSB decreased DMI (31.2, 31.3, 30.8, 30.5 kg/d; L $P = 0.01$) and milk urea nitrogen (11.3, 10.5, 9.57, 8.46 mg/dL; L $P < 0.001$) and increased yields (kg/d; all $P < 0.001$) of milk (47.8, 51.2, 51.7, 52.5; L), 3.5% FCM (48.5, 50.9, 51.7, 52.5; L), ECM (49.1, 51.3, 51.9, 52.5; L), milk fat (1.67, 1.75, 1.77, 1.83; L), and milk protein (1.57, 1.63, 1.63, 1.61 kg/d; Q $P < 0.001$). Due to the increase in milk component yields and decrease in DMI, there was an increase in feed efficiency (ECM/DMI; 1.57, 1.65, 1.69, and 1.72, L $P < 0.001$). There was no effect of treatment on BW, BW change, BCS, or BCS change (all $P > 0.20$). In summary, increasing dietary inclusion of HOSB up to 24% DM increased production responses of high-producing dairy cows by increasing yields of milk, milk fat, and milk protein.

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High oleic soybean oil maintains milk fat, increases fat digestibility, and fat deposition of lactating dairy cows.

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Due to the bioactive properties of oleic acid, the objective of this study was to feed high oleic soybean oil (HOSO) to lactating cows and evaluate milk production, body composition, and digestibility variables. Thirty Holstein cows (n = 16 primiparous, n = 14 multiparous) at (87 ± 26 DIM at start of trial) were utilized in a crossover design with periods lasting 21 d. The treatments were a control (CON) diet with no added soybean oil and a HOSO diet with 1.5% diet DM of high oleic soybean oil. Dry matter and milk production data were collected the last 7 d of each period, and milk component information was collected the last 3 d of each period. Fecal samples were collected 6 times during the last 3 d of each period. Body weights were collected on the last 3 d of each period after the morning milking and ultrasound scans of the longissimus dorsi on the last d of each period. Data were analyzed in SAS; models included the fixed effects of treatment, parity, period, the interaction between treatment and parity, and the random effect of cow. Compared with CON, HOSO did not affect DMI, milk production, and milk component yields. However, a parity effect was observed with multiparous cows having increased DMI (5.9 kg/d), milk production (11.2 kg/d), and component yields (all $P < 0.01$). Similarly, multiparous cows had increased feed efficiency (ECM/DMI kg/kg: $P < 0.01$) with no treatment differences observed for feed efficiency ($P > 0.05$). Milk fat concentration tended to be greater for HOSO cows ($P = 0.07$). Body weight data tended to have an interaction between treatment and parity, with multiparous HOSO cows having increased BW (49 kg) compared with CON with no effect in primiparous cows ($P = 0.08$). Similar treatment by parity effects were observed for BCS ($P = 0.03$). Compared with CON, HOSO increased fat depth by 0.44 mm ($P = 0.03$) and fat digestibility by 12 percentage units ($P < 0.01$). The results of this study indicated no detrimental effects of HOSO on milk production parameters with an increase in milk fat concentration, fat digestibility, and fat deposition compared with a control diet.

Palmitic (C16:0) & Oleic (C18:1) blends

2307

Fatty acid supplementation interacts with starch content to alter production responses during the immediate postpartum in dairy cows.

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We evaluated the interaction between increasing dietary starch content and fatty acid (FA) supplementation on production responses of early-lactation cows. Sixty multiparous cows were used in a randomized complete block design with a 2×2 factorial arrangement of treatments. Treatment diets were fed from 1 to 24 DIM and contained 22% or 28% diet DM starch (LS and HS) and 0% or 2% diet DM supplemental FA (NF and HF). The FA supplement was a Ca-salt containing 70% palmitic and 20% oleic acid. Treatment diets were formulated to contain 17% CP and 22% forage NDF. The statistical model included the random effect of block, cow within block and treatment, Julian date, and the fixed effects of starch content, FA supplementation, time, and their interactions. Results are presented in the following order: LSNF, HSNF, LSHF and HSHF. We observed interactions between dietary starch and FA supplementation for the yields of milk (43.1, 47.4, 43.4, 43.6 kg/d; $P < 0.05$), milk fat (1.95, 2.12, 2.13, 2.07 kg/d; $P = 0.06$), and 3.5% FCM (50.3, 55.1, 53.7, 52.7 kg/d; $P < 0.05$) because FA supplementation increased the yields of milk fat ($P < 0.05$), and tended to increase the yield of 3.5% FCM ($P = 0.09$) in the low starch diet but decreased milk yield in the high starch diet ($P < 0.05$). Overall, high starch increased the yield of milk ($P < 0.05$), tended to increase milk lactose yield (2.08, 2.27, 2.11, 2.17 kg/d; $P = 0.07$), and reduce milk protein content (3.46, 3.30, 3.38, 3.33%; $P = 0.06$), and had no effect on the yields of milk fat and protein. Overall, FA supplementation increased milk fat content (4.57, 4.48, 4.83, 4.71%; $P < 0.01$) and had no effect on the yields of milk fat and protein. In conclusion, feeding high starch diets increased milk yield during the immediate postpartum. The effect of FA supplementation on the yields of milk fat and 3.5% FCM of early-lactation cows depended on dietary starch level

- 70% C16 – 20% C18:1 C salt (equivalent to Mega-Fat 70 product) increased milk fat by 0.26% on a low starch diet, and by 0.23% on a high starch diet

1201M
Feeding a fat supplement containing palmitic and oleic acids interacts with parity in peak-lactation dairy cows during summer in Michigan.

S. R. Naughton*, M. N. Mills, J. M. Dos Santos Neto, J. S. Liesman, A. L. Lock, M. J. VandeHaar. Michigan State University East Lansing, MI.

Heat-stressed dairy cows eat less, produce less milk, and are less profitable. Fatty acid (FA) supplements sometimes mitigate heat stress. We hypothesized that a FA supplement of palmitic and oleic acids would promote milk production during warm weather. Cows (12 primiparous and 28 multiparous) in peak lactation were blocked by parity, days in milk (DIM), and milk energy/body weight and randomly assigned to a control diet (CON; corn silage-based containing 30% NDF, 17% CP, and 29% starch) or a high FA diet (HiFA; same as CON but with an extra 1.3% palmitic and 0.4% oleic acids from a Ca-salt, slightly more CP, and slightly less NDF. Cows were fed CON for 2 wk starting in mid-July and then CON or HiFA for 6 wk. Milk yield and DM intake were measured daily. Body weights were measured 3 d/wk and milk was sampled for component analysis 2 d/wk. Barn temperatures were measured continuously; daily highs ranged from 22 to 31°C and lows ranged from 14 to 23°C. Data were analyzed as repeated measures with block and cow nested within block as random effects and diet, parity, time, and their interactions as fixed effects. On average, cows ate 25 kg/d, produced 39 kg milk with 30 Mcal energy per day, and gained 0.4 kg BW per day with no overall effect of treatment, but treatment interacted with parity for intake and milk ($P \leq 0.09$). For multiparous cows, HiFA did not alter DMI, but increased milk yield 5% ($P = 0.02$) and milk energy output 5% ($P = 0.05$) compared with CON. In primiparous cows, HiFA decreased DMI (7%, $P = 0.04$) but did not alter milk yield or energy ($P = 0.4$). We found few significant correlations of treatment responses with the minimum or maximum daily temperature or temperature humidity index (THI), but max daily THI was only 76 ± 3.1 during the study. Compared with cows fed CON, HiFA increased energy-corrected milk/DMI (1.69 kg/kg vs. 1.62 kg/kg, $P = 0.01$) but did not alter milk energy per unit feed NEL. In conclusion, supplementing cows with a blend of palmitic and oleic acids increased milk yield in multiparous but not primiparous cows in summer.

1749W

Effects of palmitic and oleic acid supplementation on milk production of dairy cows milked with an automatic milking system.

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The objective of our study was to evaluate the effects of supplementing calcium salts of palmitic (PA) and oleic (OA) acid on milk production in lactating dairy cows milked with an automatic milking system (AMS). Twenty-six Holstein cows (BW; 639 ± 10.1 kg, parity; 1.81 ± 0.12) were blocked by days in milk (DIM) and assigned to 3 groups: early (0–60 DIM; n = 7), peak (61–120 DIM, n = 5), and middle and late (121- DIM; n = 14). This experiment was designed to compare milk production during a 30-d treatment period with those observed in a 14-d preliminary period preceding the treatment period. In the treatment period, all cows were fed a partial mixed ration (PMR) supplemented with 300 g of fatty-acid calcium salt (FA-Ca) per head per day; the FA-Ca was composed of 60% of PA and 30% of OA. We collected data (milk yield, milk composition, DMI) during the preliminary period and the treatment period (15 and 30 d). Preliminary milk yield (PMY) was determined during the last 3 d of the preliminary period. All data were analyzed using Proc Mixed procedure (fixed effects; group, treatment, interaction between group and treatment, PMY used as covariate, interaction between PMY and treatment, and random effect of cow). Linear effect for the interaction between PMY and treatment was added to evaluate responses to treatment by level of milk yield. Dry matter intake of PMR at 30 d of treatment period increased compared with that of 15 d in peak (21.1 vs 27.4 kg/d, $P < 0.05$), and middle and late (18.8 vs 24.0 kg/d, $P < 0.05$) groups, respectively. The de novo and preformed FA contents in milk at 30 d in the middle and late groups increased compared with that of preliminary period, respectively (de novo; 26.7 vs 23.5%, preformed; 37.7 vs 35.3%, $P < 0.05$). Interactions between treatment and PMY were detected for DMI of compound feed in AMS, 4% FCM (linear interaction); higher-producing cows (>35 kg/d milk yield) increased 4% FCM at 30 d ($P < 0.01$), and higher-producing cows (>41 kg/d) decreased DMI of compound feed at 30 d, compared with those at 15 d ($P < 0.05$). These results suggest that supplying calcium salt of PA and OA to PMR affected feed intake of lactating cows, and the long-term supplementation of these calcium salts may affect milk production of cows producing milk greater than 35 kg/d in AMS.

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1200M

Different ratios between palmitic and oleic acids in calcium salts of fatty acids form greatly influenced the digestibility and production performance of dairy cows.

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The form of fat supplements, degree of saturation, and the fatty acids (FA) profile influence the cow's productive response. The objective was to examine the effects of supplemental fats in the form of calcium salts of fatty acids (CSFA) in different ratios between palmitic (PA) and oleic (OA) acids on nutrient digestibility and cows' performance. Forty-two dairy cows were assigned into 3 groups and fed for 13 wk rations containing 2.2% of CSFA (on DM basis) consisting of 1) CS45:35: 45% PA and 35% OA; 2) CS60:30: 60% PA and 30% OA; and 3) CS70:20: 70% PA and 20% OA. Rumen and fecal samples were taken for VFA and digestibility measurements, respectively. Production data were analyzed with PROC MIXED, and rumen and digestibility data with GLM models of SAS. Milk yields were the highest in the CS45:35 (52.0 kg/d), intermediate in the CS60:30 (51.1 kg/d), and lowest in the CS70:20 cows (47.3 kg/d; P = 0.002). Milk fat content was ~0.35 percentage units lower in the CS45:35 cows than in the other 2 groups (3.55, 3.94, and 3.87% in the CS45:35, CS60:30, and CS70:20 groups, respectively; P = 0.001), and fat yields were higher in the CS60:30 than in other groups (P = 0001). The FCM 4% and ECM yields were higher in the CS60:30 than in other groups. Feed intake was highest in the CS60:30 group (33.5 kg/d) and lowest in the CS70:20 group (31.3 kg/d; P = 0.001). The milk-to-DMI ratio was the highest in the CS45:35(P = 0.001), with no differences in the efficiency for 4% FCM or ECM production. In conclusion, increasing the PA proportion in the fat supplements greatly increased the milk-fat content, and a high OA ratio increased the milk yields. The digestibility of most nutrients was lower in the CS70:20 than in other groups; however, the total fat digestibility was similar between all groups, indicating that the form more than the FA profile influences the fat digestibility. The different impacts of the PA-to-OA ratio in the fat supplements indicates that in the future the FA profile of the provided supplement will be determined according to the defined goal: milk or milk-fat.

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Effects of oleic and palmitic acids levels in a fat supplement on milk production in lactating dairy cows.

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Fatty acid (FA) supplements are fed to increase energy intake and positively impact milk and milk fat yield. Fat supplements commonly differ in oleic (OA) and palmitic (PA) acids concentration which may impact milk fat yield, digestibility, and nutrient partitioning. Our objective was to investigate the effects of increasing OA or PA in a prilled fatty acid supplement. We hypothesized increasing PA will increase milk fat yield and increasing OA will increase FA digestibility and milk yield. Eight multiparous and 8 primiparous Holstein cows (>70 DIM) were blocked by parity and randomly assigned to a sequence in a 4 × 4 Latin square design with 21 d periods. Treatments were 1) low fat control (CON), 2) high fat control (HF; 59% PA, 22% SA, and 10% OA), 3) high oleic supplement (HO; 60% PA, 18% SA, and 13% OA) and 4) high palmitic supplement (HP; 73% PA, 12% SA, and 9% OA). The FA supplements were fed at 2.0% of DM intake. Data were analyzed using the MIXED procedure of SAS. The model included the random effects of cow and period and the fixed effect of treatment, parity, and their interaction. Preplanned contrasts compared the low and high fat controls and effects of increasing oleic acid (HF vs HO) and palmitic acid (HF vs HP). The conventional fat increased milk fat yield regardless of parity compared with the low fat control (1.44 vs 1.52 kg/d, $P < 0.01$) and in multiparous cows also increased milk yield (41.1 vs 43.3 kg/d; $P = 0.03$) and protein yield (1.26 vs 1.32 kg/d; $P = 0.03$). Increasing OA in the supplement increased milk yield (40.1 vs 41.8 kg/d; $P = 0.02$) and milk fat yields (1.52 vs 1.58 kg/d; $P = 0.02$). Increasing PA did not change milk or milk fat yield compared with the conventional FA supplement. Fat supplementation increased 16 C and decreased de novo and preformed FA. Increasing OA had no effect on the sum of milk FA < 16, 16, and > 16 C FA, while increasing PA increased 16C FA in multiparous cows. Overall, fat supplementation improved milk fat yield and the observed benefit with increased OA may be due to changes in FA digestibility or nutrient partitioning.

- Fat supplements with 59-73% C16 increased milk yield by over 2 kg/d in multiparous cows

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Production responses to fatty acid supplementation are impacted by fatty acid profile rather than form of the supplement.

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We determined the effects of fatty acid (FA) profile vs the form of a FA supplement on production responses of post-peak dairy cows. Twenty multiparous Holstein cows (44.3 ± 3.00 kg/d of milk; 99 ± 23 DIM) were randomly assigned to treatment sequences in a replicated 4x4 Latin square design with 21-d periods. Treatments were a non-FA supplemented control diet (CON) and 3 diets incorporating FA supplements at 2.0% DM of total FA of 1) blend of FA supplements to achieve a ratio of 70% C16:0 + 20% C18:1 using FA prills and Ca-salts (FAB), 2) a Ca-salt containing 70% C16:0 + 20% C18:1 (SLT), and 3) a Ca-salt of palm FA distillate containing 55% C16:0 + 35% C18:1 (TRD). The 3 FA treatments replaced soyhulls in the CON diet. Diets contained similar (%DM) NDF (29.8%), forage NDF (18.4%), starch (28.6%), and CP (17.3%). The statistical model included the random effect of cow within square and the fixed effects of treatment and period. Pre-planned contrasts included CON vs the average of the 3 FA treatments (FAT), the form of the FA supplement (FAB vs SLT), and the FA profile of the Ca-salt (SLT vs TRD). Results in the text are presented in the following order: CON, FAB, SLT, and TRD. Overall, FAT increased 3.5% FCM (48.2, 49.0, 49.2, 49.5 kg/d; $P = 0.01$) and milk fat yield (1.72, 1.76, 1.79, 1.75 kg/d; $P = 0.01$) but decreased DMI (31.0, 30.9, 30.4, 29.4 kg/d; $P = 0.02$) and milk protein yield (1.54, 1.49, 1.48, 1.50 kg/d; $P < 0.001$). There was a tendency for SLT to increase milk fat yield ($P = 0.08$) compared with FAB, but there were no other differences in production responses for FAB vs SLT ($P > 0.33$). Compared with SLT, TRD decreased DMI ($P = 0.02$) and tended to decrease milk fat yield ($P = 0.07$), but increased milk yield ($P < 0.001$) and tended to increase milk protein yield ($P = 0.08$). In conclusion, overall FAT increased yields of milk and milk fat but decreased DMI. There were no differences between the 70% C16:0 + 20% C18:1 supplement fed as a blend or a Ca-salt. However, a traditional Ca-salt decreased DMI compared with the 70:20 Ca-salt, indicating that the FA profile of a FA supplement is more important than the form.

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Lysophospholipids

1743W

Effects of fatty acid supplements and lysophospholipids on nutrient digestibility in lactating cows.

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The objective of the present study was to investigate changes in nutrient digestibility affected by saturated fatty acids (FA) sources and lysophospholipids (LPL), a natural emulsifier, supplementation. Total 48 mid-lactation cows blocked by parity and days in milk were used in a randomized complete block design. Cows within block were assigned randomly to the following treatments: Diet supplemented with 1) FA (1.8% of diet DM), primarily palmitic acid (PA); 2) FA, primarily stearic acid (SA); 3) PA and LPL (0.003% of diet DM); 4) SA and LPL. The experiment was conducted for 6 wk. Spot samples of feces were taken over 3 d (every 3 h within a 24-h cycle) during the last week of the experiment to assess total-tract digestibility of nutrients. The mixed model was used for statistical analysis with FA, LPL, and their interaction as fixed effects and block as a random effect. DMI was not affected by FA and LPL. The FA source did not affect the digestibility of DM, OM, and CP, and there was no interaction between FA and LPL. However, PA increased (41.4 vs. 38.8%; $P = 0.04$) NDF digestibility compared with SA without an interaction between FA and LPL. Supplementation of PA decreased the digestibility of 16-carbon FA (47.6vs. 59.1; $P < 0.01$) compared with SA, and SA decreased the digestibility of 18-carbon FA (65.3 vs. 77.0; $P < 0.01$) compared with PA. While LPL did not affect the digestibility of DM, OM, CP, and NDF, it increased FA digestibility (64.7 vs. 60.5%; $P = 0.02$) compared with no LPL. Furthermore, LPL increased (74.1 vs. 68.2%; $P < 0.01$) 18-carbon FA digestibility without an interaction with FA, but an interaction between FA and LPL was observed for 16-carbon FA digestibility, which occurred because LPL increased 16-carbon FA digestibility with SA but not with PA. In conclusion, we confirmed that fiber digestibility can be enhanced by PA but not by SA. Supplementation of LPL may be beneficial in increasing FA digestibility when used with a FA supplement containing primarily SA. Further research would be required to comprehend how LPL interacts with different FA sources.

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Effects of abomasal infusion of lecithin from different sources on milk production and nutrient digestibility in lactating dairy cows.

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Phospholipid composition due to origin source may impact the outcome of dietary phospholipids to enhance fat digestion. Eight multiparous Holstein cows (99.4 ± 9.2 d in milk [DIM]; 48.9 ± 3.8 kg milk yield [MY]/d) were enrolled in a 3 × 3 incomplete Latin square design with 3 treatments provided as continuous abomasal infusates spanning 14-d experimental periods: water (CON), soybean lecithin (SOY; 28% phosphatidylcholine [PC]; 3% lyso-PC [LPC], 74.5 g of BergaPur; Berg+Schmidt); or sunflower lecithin (SUN; 23% PC, 14% LPC, 133.5 g of BergaThin SF Lyso; Berg+Schmidt). Cows were fed a corn silage-based diet (47% DM, 27% NDF, 26% starch, 5.1% EE). The statistical model included the fixed effects of treatment, period, square, treatment × period, and the random effect of cow. Tukey's test was performed for mean comparisons. Dry matter intakes were not affected by treatment. SUN cows had greater MY than SOY and CON (49.1, 46.4, and 45.4 kg/d, respectively; $P < 0.05$). SUN cows tended to produce more energy-corrected milk [ECM] than SOY and CON ($P = 0.10$). SUN cows had greater feed efficiency [MY/DMI] than SOY and CON ($P < 0.05$). Milk fat, protein, and lactose contents were not affected by treatment ($P > 0.05$). Although milk fat yield was not modified by treatment, yields of total solids and protein were greater in SUN than SOY and CON ($P < 0.05$). Treatment did not modify plasma glucose, fatty acid, or insulin concentrations ($P > 0.05$). SUN cows had greater total fatty acid [TFA] and 18C intake than SOY and CON ($P < 0.05$); however, C16 intake was not modified by treatment ($P > 0.05$). Treatment did not modify dry matter, TFA, 16C, or 18C digestibility ($P > 0.05$). De novo (<16C) milk fatty acid concentrations were greater in SOY and SUN, relative to CON ($P < 0.05$). Milk mixed (16C) fatty acid concentrations were greater in CON than SOY and SUN ($P < 0.05$). Milk preformed (>16C) fatty acids concentrations were higher in SUN than SOY and CON ($P < 0.05$). Abomasal infusion of lecithin from different sources did not modify fatty acid digestibility; however, yields of milk and milk protein were uniquely modified by dietary phospholipid source.

- Lecithin had no effect on FA digestibility addition
- Sunflower lecithin increased milk yield

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Stearic acid (C18:0)

1796W

Performance of ewe lambs fed stearic acid (C18:0).

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Lipid supplements have been used both to supply energy needs when these are compromised and in periods of positive energy balance. However, fatty acids differ in their metabolic functions and partition, in this sense, stearic acid (C18:0) has been the subject of studies that evaluate animal performance and development. The objective of this study was to evaluate C18:0 on the performance of growing ewe lambs. Eight ewe lambs (Lacaune x Texel), weighing 35 ± 2.8 kg in a completely randomized design, were assigned the following treatments: 1) Control and 2) 1.5% of the dry matter intake (DMI) of C18:0 (87% of C18:0). The experiment lasted 63 d and the basal diet was formulated according to the SRNS (2010), consisting of corn silage and concentrate. The concentrate was fed individually and the corn silage per group, twice a day, in the proportion of 110% of voluntary DMI. The DMI evaluation was performed daily and adjusted every 21 d according to the development of the animals. The diets were isoenergetic and isoproteic. Body condition score (BCS) and body weight (BW) assessment were performed on d 0, 21, 42 and 63. The average daily gain (ADG) was obtained individually according to development during the 63 d. Data were analyzed by SAS University (2017) using PROC MIXED, with treatment as a fixed effect, animals as a random effect and data normality was tested. Animals supplemented with C18:0 showed higher BCS and a reduction of 15.8% and 8.6% in DMI of concentrate and silage, respectively, compared with the control treatment (Table 1). The ADG and BW did not differ between treatments. Overall, feeding C18:0 improves BCS and reduces DMI without affecting ADG and BW of ewe lambs.

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Omega-3 fatty acids

2312

Production performance and nutrient digestibility in grazing dairy cows fed an extruded flaxseed-based supplement.

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Eighteen multiparous and 2 primiparous Jersey cows (128 ± 52 DIM) were used in a randomized complete block design to investigate the effects of an extruded flaxseed-based supplement (LinPRO-R) on production performance and nutrient digestibility during the grazing season. Cows grazed a mixed grass-legume pasture (herbage allowance = 15 kg of DM/cow daily) overnight and received a partial total-mixed ration (pTMR) during the day. The pTMR were formulated to contain (DM basis) 37.5% mixed, mostly legume baleage and 62.5% of a soybean meal/ground corn-based concentrate mash. Cows were randomly assigned to 1 of 2 diets: (1) pasture plus pTMR (control = CTRL) or (2) pasture, pTMR, and 6% LinPRO-R (LIN). Ground corn and soybean meal were replaced with LinPro-R in the LIN diet. Diets were formulated to be isonitrogenous and to yield a 60:40 forage to concentrate ratio. Pasture averaged 17.5% CP and 53% NDF, and pTMR 9.7% CP and 15% NDF. The experiment lasted 12 wk with 2 wk for a covariate period followed by 3 sampling periods during wk 4, 7, and 10. Individual herbage intake was estimated using $Cr2O3$ and in vitro DM digestibility of feeds. Fecal grab samples were taken 8 times over 5 d in each sampling period. Data were analyzed using the MIXED procedure of SAS with repeated measures over time. Herbage intake was lower (7.52 vs. 6.92 kg/d; $P < 0.01$) in LIN compared with CTRL, and pTMR intake tended to increase with feeding LIN (14.9 vs. 14.5 kg/d; $P = 0.07$). However, total intake of DM, OM, CP, and NDF was not affected by treatments. Similarly, milk yield (mean = 27 kg/d), concentrations and yields of milk fat and milk protein were not changed when cows received CTRL or LIN. In contrast, MUN concentration was lower ($P < 0.001$) in LIN (8.38 mg/dL) than CTRL (11.0 mg/dL). Treatments had no effect on the apparent total-tract digestibilities of DM (mean = 61%), OM (mean = 63%), CP (mean = 56%), and NDF (mean = 53%). Furthermore, no treatment effects were observed for BW change and BCS. In summary, LinPRO-R fed at 6% of diet DM did not affect milk yield and nutrient digestibility in grazing dairy cows.

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Supplementation of omega-3 fatty acids as a strategy to regulate postpartum inflammation.

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Our objective was to investigate the effects of dietary supplementation of omega-3 (n3) fatty acids (FA) on physiological responses to lipopolysaccharide (LPS) challenge in early postpartum cows. Healthy cows were blocked by parity and BCS and randomly assigned to 1 of 3 top-dress treatments at 2 d in milk (DIM): 1) unsupplemented control received basal diet top-dressed with high moisture corn at 0.8% of dry matter (DM) (UNSUP; n = 16); 2) isocaloric control received UNSUP diet plus calcium salts (CaS) of palm oil at 0.8% of DM (CaPO; n = 8); or 3) n3 supplemented group received UNSUP diet plus CaS of fish oil at 0.8% of DM (CaFO; n = 8). At 14 DIM, UNSUP were assigned to 1 of 2 IV infusions: 1) LPS at 0.0625 µg/kg of BW (UNSUP-LPS; n = 8) or 2) saline (UNSUP-CON; n = 8). All fat-supplemented cows received LPS IV at 14 DIM. Blood, milk and peripheral blood leukocytes (PBL) were collected from 2 to 21 DIM and hourly for 12 h after challenge for analyses of FA composition, metabolites and markers of immune response. Data were analyzed using mixed models considering treatment, time, parity, BCS, their interactions and random effect of cow. Compared with UNSUP, fat supplementation decreased DM intake but did not impact energy-corrected milk yield. Fat increased concentration of monocytes in whole blood at 14 DIM (0.27 vs.0.38 ± 0.04 ×109 cells/L). CaFO resulted in greater ($P < 0.01$) % composition of EPA and DHA in plasma (1.8 vs.1.9 vs.3.4 ± 0.1%) and milk (0.096 vs.0.089 vs.0.173 ± 0.01%), as early as 7 DIM, and increased abundance of EPA in phospholipids of PBL at 14 DIM (1.47 vs.1.48 vs.1.8 ± 0.1%; $P = 0.05$). Body temperature increased in all LPS IV cows and did not change in UNSUP-CON. Compared with UNSUP-LPS and CaPO, CaFO spent less ($P = 0.08$) time above 40°C following infusion (245 vs.225 vs.169 ± 23 min) and had a smaller ($P = 0.06$) area under the curve above 40°C (16,164 vs.1,5301 vs.1,1396 ± 1,427 arbitrary units). Before and after infusion, concentration of IFNγ was higher ($P = 0.06$) in CaFO and macrophage inflammatory protein-1α was higher ($P < 0.01$) in CaFO than in CaPO. In conclusion, postpartum n3 supplementation via CaFO modestly altered inflammatory responses in early lactation.

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2463
Effects of omega-3 fatty acid supplementation on the reproduction system in cows and bulls.

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Mammals can synthesize all of the essential fatty acids (FA), except those belonging to the omega-3 (n-3) and omega-6 (n-6) families, which should be supplied in the diet. Common feedstuffs are rich in n-6 FA, whereas the supply of n-3 FA in the intensive dairy industry is mainly limited to flaxseed and fish oils. The n-3 FA are involved in many biological processes, such as the reproductive and immune systems, and therefore their dietary supplementation in dairy cattle is of special interest. In a series of studies, we investigated the rate and total infiltration of n-3 fatty acids into the ovarian compartments in cows, and sperm in bulls, and consequently their physiological effects. Interestingly, selective-uptake mechanism of the n-3 FA has been demonstrated in the ovary compartments, as well as in bull sperm. For example, the content of eicosapentaenoic (EPAn-3), which originated from fish oil, was high in oocytes, but was not found in the follicular fluid. On the other hand, docosapentaenoic acid (DPAn-3), which is synthesized de novo from shorter n-3 FA, accumulated only in oocytes. We also found that a specific time period is required for the infiltration of dietary n-3 FA into the target tissues; this was particularly salient in bulls, but also applies to cows. The incorporation of these unique FA into the reproductive system exerts some positive effects on fertility. The intensity, duration, timing, and pattern of hormones' secretion around estrus were influenced by n-3 supplementation. In addition, we performed ovum pick-up, in vitro maturation, and oocyte fertilization, and found a higher cleavage rate in cows supplemented with n-3 FA. In bulls, the enrichment of sperm with n-3 FA improved the survival and quality of fresh and freeze–thawed semen. Furthermore, we found that the beneficial effects obtained for the reproductive system in cows and bulls from feeding n-3 FA can be achieved with the supplementation of α-linolenic acid (ALA) from flaxseed. In conclusion, dietary n-3 FA are incorporated into the compartments of the reproductive system in cows and bulls, and exert several beneficial effects.

- Summary of benefits of omega-3, including from flaxseed – as supplied by Mega-Flax

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1390T

Effects of feeding cows a high omega-3 fatty acids diet in milk and dairy products quality.

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Omega-3 fatty acids are known for their health benefits thus the interest to increase their content in dairy products. A few studies have explored the enrichment of dairy products with vegetable sources and animal sources of omega-3, however, the latter is known to produce a “fishy” taste. In this sense, the objective of this project is to evaluate the quality of milk and dairy products by feeding Holstein and Jersey cows with an omega-3 enriched diet. For this purpose, the treatments included control consisting of 20 Holstein (HC) and 20 Jersey cows (JC), enriched omega-3 feed at an 8% ratio to 20 Holstein Cows (H8%), and enriched omega-3 feed at a 6% ratio to 20 Jerseys (J6%) and 20 Holstein cows (H6%). The feeding trial was conducted over 90 d. At the end of the trial, the milk was collected and cheese, cream, and butter were obtained from the control milk, H8%, and J6% to identify potential off-flavors. For all samples, a fatty acid profile was completed using method AOAC 996.06 (2012). ANOVAs were used for statistical analysis. Results showed that no differences were found for the dry matter intake with each treatment, mean milk production significantly increased in J6% but not in H8%. No significant differences were found for the omega-3 fatty acid concentration in milk but the content was higher at the end of the trial for J6% and H8%. For dairy products, the content of omega-3 was higher in H8% and J6% cheeses compared with control by 2.16 and 1.71 times respectively, while cream and butter also showed an increase in the concentration of omega-3 for H8% and J6% compared with the control treatment. In conclusion, the results obtained from this study are promising as the mean milk production was significantly increased in Jerseys fed with LinPro-R at a rate of 6%, increasing pounds of fat, and protein. The omega-3 fatty acids were concentrated in cheese, cream, and butter.

Cottonseed

1203M

Effect of increasing dietary inclusion of whole cottonseed on milk production of high-producing dairy cows.

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We determined the effect of increasing dietary inclusion of whole cottonseed (WCS) on production responses of high-producing dairy cows. Twenty-four multiparous Holstein cows (52.7 ± 2.63 kg/d of milk; 104 ± 23 DIM) were randomly assigned to treatment sequences in a replicated 4 × 4 Latin square design with 21-d periods. Treatments were increasing doses of WCS at 0, 8, 16, and 24% DM. Whole cottonseed replaced soybean meal and hulls to maintain similar diet nutrient composition (%DM) of 32.5% NDF, 17.1% forage NDF, 26.9% starch, and 17.5% CP. Total FA content of each treatment was 1.70, 2.96, 4.20, and 5.40%DM, respectively. The statistical model included the random effects of period and cow within square and the fixed effect of treatment. Pre-planned contrasts included the linear (L), quadratic (Q), and cubic (C) effects of increasing WCS. Results in the text are presented in the following order: 0%, 8%, 16%, and 24% WCS. Increasing WCS affected DMI (34.4, 35.2, 34.6, 32.5 kg/d; Q, $P < 0.001$) and yields (kg/d; all $P < 0.001$) of milk (50.9, 52.9, 52.5, 50.4; Q), 3.5% FCM (52.3, 55.0, 54.8, 50.4; Q), ECM (52.6, 54.8, 54.6, 51.7; Q), milk fat (1.87, 1.98, 1.97, 1.85; Q), and milk protein (1.65, 1.67, 1.65, 1.55; Q). Increasing WCS increased BW change (0.26, 0.25, 0.50, 0.54 kg/d; L, $P = 0.02$), did not affect BCS change ($P = 0.26$), and decreased plasma insulin (0.96, 0.90, 0.92, 0.87 ug/mL; L, $P < 0.01$). Increasing WCS decreased yields (g/d; all $P < 0.001$) of de novo FA (503, 500, 457, 386; L) and mixed FA (674, 664, 632, 576; L), but increased preformed FA (565, 689, 761, 784; L). There was an increase in the FA content (g/100g) of trans-10 C18:1 in milk fat (0.46, 0.47, 0.54, 0.56; L, $P < 0.001$), suggesting altered biohydrogenation pathways. Increasing WCS in treatments increased gossypol intake (0.00, 18.6, 36.8, 52.0 g/d); thus there was an increase in plasma gossypol content (0.91, 2.46, 4.09, 6.15 ug/mL; L, $P < 0.001$). In summary, increasing dietary inclusion of WCS up to 16% DM increased production responses in high-producing cows. The 24% WCS diet reduced DMI, milk production yields, and plasma insulin.

- Whole cottonseed increased milk yield and milk fat yield up to 16% inclusion

1202M

Effect of increasing dietary inclusion of whole cottonseed on nutrient digestibility of high-producing dairy cows.

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We determined the effect of increasing dietary inclusion of whole cottonseed (WCS) on nutrient digestibility of high-producing dairy cows. Twenty-four multiparous Holstein cows (52.7 ± 2.63 kg/d of milk; 104 ± 23 DIM) were randomly assigned to treatment sequences in a replicated 4 × 4 Latin square design with 21-d periods. Treatments were increasing doses of WCS at 0, 8, 16, and 24% DM. Whole cottonseed replaced soybean meal and hulls to maintain diet nutrient composition (%DM) of 32.5% NDF, 17.1% forage NDF, 26.9% starch, and 17.5% CP. Total FA content of each treatment was 1.70, 2.96, 4.20, and 5.40%DM, respectively. The statistical model included the random effects of period and cow within square, and the fixed effect of treatment. Pre-planned contrasts included the linear (L), quadratic (Q), and cubic (C) effects of increasing WCS. Results in the text are presented in the following order: 0%, 8%, 16%, and 24% WCS. There was an effect of increasing WCS for intakes (kg/d; both $P < 0.001$) of DM (34.4, 35.2, 34.6, 32.5; Q) and NDF (11.2, 11.4, 11.2, 10.4; Q) and intakes (g/d; all $P < 0.001$) of 16-carbon (84.9, 195, 291, 364; L), 18-carbon (494, 857, 1167, 1400; L), and total FA (593, 1075, 1490, 1802; L). Increasing WCS affected digestibility of DM (65.6, 63.7, 65.1, 66.8%; Q, $P < 0.001$) and NDF (45.2, 41.9, 43.5, 45.8%; Q, $P < 0.01$), and increased digestibility of 16-carbon FA (71.6, 75.7, 75.9, 77.8%; C, $P = 0.01$) and decreased digestibility of 18-carbon (80.1, 76.2, 71.6, 71.2%; L, $P < 0.001$) and total FA (77.8, 75.6, 72.3, 72.5%; C, $P = 0.03$). There was an increase in the amount of absorbed (g/d; all $P < 0.001$) 16-carbon (60.4, 147, 221, 284; L), 18-carbon (386, 653, 835, 1001; L), and total FA (451, 812, 1075, 1313; L). In summary, increasing dietary inclusion of WCS from 0 to 24% DM inclusion increased intake and absorbed 16-carbon, 18-carbon, and total FA. Furthermore, WCS inclusion at 24% decreased DMI and NDF intake. Despite the decrease in total FA digestibility with increasing dietary WCS inclusion, absorbed total FA increased by 361, 624, and 862 g/d, respectively.

Experts in fat nutrition

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