

Effects of rumen-protected fatty acid saturation on milk yield, feed intake, chewing behavior, and ruminal fermentation in lactating dairy cows.

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Published Work

- Harvatine and Allen-
 - *JDS* 2005; 88(11):4018
 - *JDS* 2006; 89(3):1081
 - *JDS* 2006; 89(3):1092
 - *JDS* 2006; 89(3):1104
- *J Nut* 2006; 136(3):677

Introduction

- Absorbed fuels are not the same
- Absorbed Fuels Interacts With
 - *Metabolism*
 - *Physiology*
- Absorbed Fuels ≠ Simply Energy

Introduction

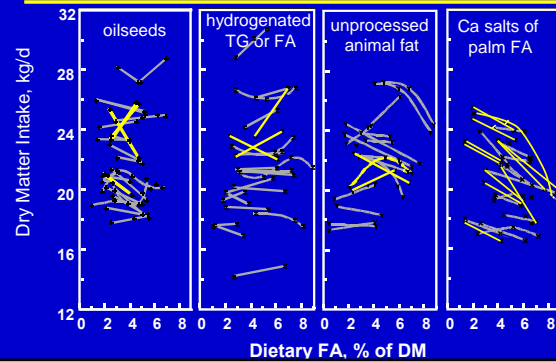
- Application of Dietary FA
 - *Energy*
- Modify physiology
 - *Intake*
 - *Reproductive efficiency*
 - *Milk fat synthesis*
 - *Nutrient partitioning*
 - *Ruminal fermentation*

FA and the Rumen

- Rumen transforms FA
 - Biohydrogenation
- Rumen is transformed by FA
- Fat supplements
 - Calcium salts
 - Prilled hydrogenated free FA
 - Oilseeds protected in seedcoat
 - Amides, formaldehyde coating, encapsulation etc

Fat Sources and Intake

Allen, 2000, J. Dairy Sci. 83:1598



Direct Experimental Evidence

- Abomasal infusion of unsaturated fat decreases intake relative to saturated fat
(Drackley et al., 1992, Christensen et al., 1994, Bremmer et al., 1998)
- Unsaturated FFA decrease intake to a greater extent than TG possibly due to increased GLP-1
(Litherland et al. 2005)

Objective

Substitute unsaturated FA for saturated FA and evaluate responses of feed intake and chewing behavior, milk yield and composition, and ruminal fermentation.

Two Experiments

Crossover

- Establish DMI and production response
- Observe response by milk yield?

Latin Square

- Ruminally and duodenally cannulated cows
- Intensive observations

Crossover- Experimental Design

- 32 cows
- Treatment- 2.5% FA
 - SAT (Energy Booster 100®)
 - UNS (Megalac®)
- Diets contained 10.3% cottonseed
- Final diet ~ 7% total fat, 25.5% starch and 26.5% NDF

Crossover- Production Response

	SAT	UNS	SE	P
Milk, kg/d	41.8	42.4	1.1	0.09
Milk Composition				
Fat, %	3.57	3.53	0.09	0.39
Protein, %	3.07	3.02	0.05	0.02

Crossover- Intake and Behavior

	SAT	UNS	SE	P
DMI, kg/d	27.4	26.6	0.4	<0.01
Chewing Time, Min/d				
Eating	210	205	6	NS
Ruminating	535	510	10	<0.01
Idle	665	695	13	<0.01

Crossover- Hormones and Metabolites

	SAT	UNS	SE	P
Insulin, μ IU/mL	12.8	10.1	0.55	<0.001
NEFA, mM	91.1	115	3.5	<0.001
CCK, pmol/L	12.5	14.1	0.91	0.08

Crossover- Summary

- Ca salts palm oil decreased intake relative to saturated free fatty acids
- Saturated FFA increased time spent ruminating but did not decrease time spent eating
- Hydrogenated free fatty acids increased insulin 25% and decreased plasma NEFA

Latin Sq- Experimental Design

- 8 ruminally and duodenally cannulated cows
(76 DIM, 1.9 BCS)
- 4 x 4 Latin square (n = 2)
- Treatments
 - Con (rice hulls)
 - Sat (Energy Booster 100[®])
 - Int (50:50 Sat:Uns)
 - Uns (Megalac R[®])
- All diets contained 13.5% cottonseed

Treatment FA Profile

Nutrient	Uns	Sat
	-----% Total FA-----	
C16:0	31.9	29.9
C18:0	4.34	52.8
C18:1	31.7	7.65
C18:2	25.2	1.59
C18:3	1.52	0

Diet composition

%DM	Con	Sat	Int	Uns
Total FA	5.5	8.3	8.1	7.8
Unsat FA	3.6	3.9	4.4	4.9
Starch	30.8	30.3	30.5	30.7
NDF	29.1	27.3	27.5	27.7

Milk Yield and Composition

	Con	Sat	Int	Uns	SE	P		
						RPF	L	Q
MY, kg/d	47.0	46.6	45.2	43.7	2.7	0.10	0.02	NS
Protein, %	2.84	2.88	2.89	2.96	0.08	NS	NS	NS
Fat, %	3.06	2.93	2.78	2.43	0.2	0.01	<0.01	NS

Milk Fatty Acid Profile, % FA

	Con	Sat	Int	Uns	SE	P		
						RPF	L	Q
trans-C18:1	3.16	2.96	4.14	6.27	0.39	<0.01	<0.01	NS
c9,t11 CLA	0.01	0.02	0.03	0.05	0.005	<0.01	<0.01	0.13
t10,c12 CLA	0.02	0.03	0.04	0.08	0.006	<0.01	<0.01	<0.01

Duodenal FA Flow, g/d

	Con	Sat	Int	Uns	SE	P		
						RPF	L	Q
C16:0	290	440	430	350	30	<0.01	<0.01	NS
C18:0	580	880	680	470	53	0.07	<0.01	NS

Duodenal FA Flow, g/d

	Con	Sat	Int	Uns	SE	P		
						RPF	L	Q
C16:0	290	440	430	350	30	<0.01	<0.01	NS
C18:0	580	880	680	470	53	0.07	<0.0	NS
trans-C18:1	160	170	280	260	24	<0.01	<0.01	0.02
cis-C18:1	75	84	100	100	6.3	<0.01	<0.01	NS
C18:2	94	100	99	97	6.6	NS	NS	NS
C18:3	7.4	7.8	7.6	6.6	0.4	NS	0.04	NS

Rumen Biohydrogenation

	Con	Sat	Int	Uns	SE	P		
						RPF	L	Q
Biohydrogenation Extent, %								
C18:3	81.8	80.2	82.9	84.9	1.1	NS	<0.01	NS
C18:2	86.4	84.5	86.1	86.6	0.77	NS	0.02	NS
trans-C18:1	90.5	90.1	82.0	83.0	2.1	0.02	0.01	0.06
cis-C18:1	69.0	68.0	69.1	71.6	1.8	NS	NS	NS

Ruminal pH

	Con	Sat	Int	Uns	SE	P		
						RPF	L	Q
Mean	5.97	5.99	6.05	6.01	0.06	NS	NS	NS
Minimum	5.42	5.34	5.42	5.42	0.05	NS	NS	NS

Summary- Ruminal FA Metabolism

- C18:2 and C18:3 not protected when fed as Ca salt
- UNS
 - decreased trans-C18:1 biohydrogenation
 - Increased duodenal flow of trans-C18:1
- Shift in ruminal biohydrogenation towards isomers known to decrease milk fat synthesis

Intake and Feeding Behavior

	Con	Sat	Int	Uns	SE	P		
						RPF	L	Q
DMI, kg/d	27.3	25.7	25.1	24.1	1.0	<0.01	0.02	NS
Feeding Behavior								
Size, kg	2.51	2.50	2.54	2.28	0.15	NS	0.03	0.07
Meals/d	10.1	10.2	10.0	10.6	0.6	NS	NS	NS

Ruminating Behavior

	Con	Sat	Int	Uns	SE	P		
						RPF	L	Q
Total, min/d	574	616	568	560	15	NS	<0.01	0.16
Length, min	44.2	48.1	43.0	42.5	1.6	NS	<0.01	0.10
Bouts/ d	13.3	13.0	13.6	13.5	0.5	NS	NS	NS

Rumen Pools

	Con	Sat	Int	Uns	SE	P		
						RPF	L	Q
Wet, kg	86.6	85.7	80.7	74.4	3.7	0.09	0.02	NS
Volume, L	101	97	93	89	4	0.04	0.05	NS

Summary

- Intake
 - Uns
 - decreased intake
 - decreased meal size
 - decreased rumen fill
- Chewing Behavior
 - Sat
 - Increased rumination
 - Increased rumination bout length

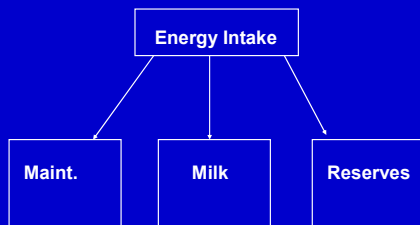
Energy Balance

	Con	Sat	Int	Uns	SE	RPF	P L	Q
DE Intake Mcal	78.0	75.3	74.0	70.1	3.1	0.04	0.06	NS
NE _L Milk Mcal/d	29.8	28.6	27.5	25.8	1.67	<0.01	<0.01	NS

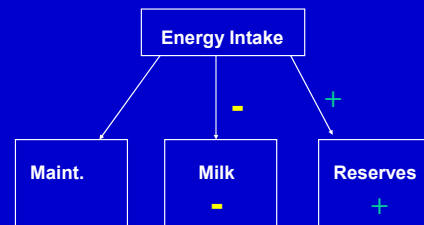
Energy Balance

	Con	Sat	Int	Uns	SE	RPF	P L	Q
DE Intake Mcal	78.0	75.3	74.0	70.1	3.1	0.04	0.06	NS
NE _L Milk Mcal/d	29.8	28.6	27.5	25.8	1.67	<0.01	<0.01	NS
E-BW Δ , kg/d	0.21	0.11	0.49	0.94	0.24	NS	0.02	NS
NE _L BW Mcal/d	1.06	0.43	2.14	4.16	1.03	NS	0.02	NS

Energy Balance



Energy Balance



Conclusion

- Calcium Soaps did not protect PUFA
- Unsaturated FA
 - Decreased milk fat synthesis
 - Increased duodenal trans-FA flow
 - Decreased intake
 - Linearly increased tissue energy gain

Conclusion

- Saturated FA
 - Did not decrease intake
 - Increased rumination



NOTES:

