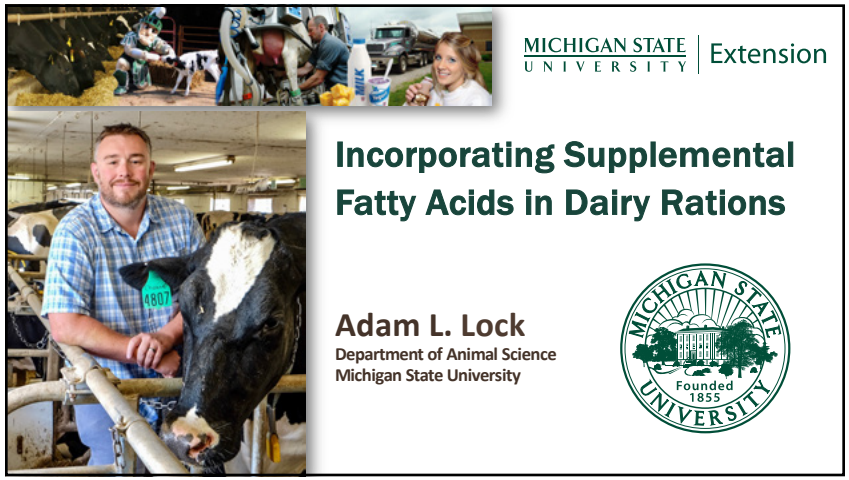
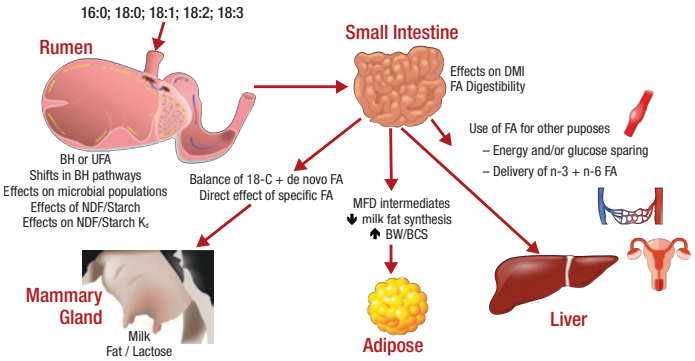


Impact of Dietary Fatty Acids on Digestion, Metabolism, and Nutrient Use in Lactating Dairy Cows



Effects of Supplemental Fatty Acids on Lactating Dairy Cows:

Will discuss and answer (hopefully) questions related to:

- Do supplemental FA impact NFD digestibility?
- Do all dietary FA have the same digestibility?
- Does the effect of fat supplements on FA digestibility matter?
- Do all sources of supplemental FA have the same impact on yield of milk and milk components?
- Do cows at different levels of milk production respond differently to blends of supplemental FA?
- Can different FA impact energy partitioning?
- Should we feed supplemental FA to early lactation dairy cows?

➢ Are all fat supplements the same?

Why do you chose to feed fatty acid (fat) supplements to lactating cows?

- ○ I do not feed fatty acid (fat) supplements
- ○ Reduce body weight loss
- ○ Increase yield of milk and milk components
- ○ Improve reproduction
- ○ It depends

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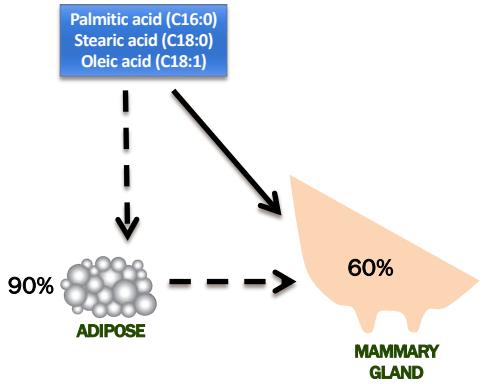
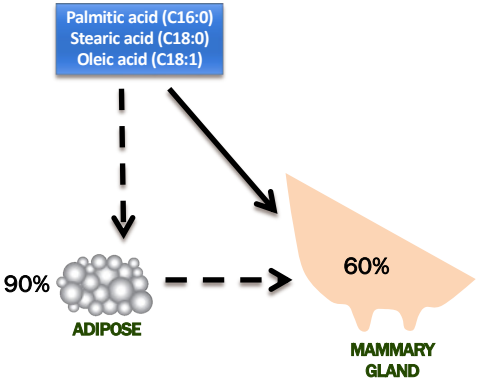
Recent Focus on Palmitic, Stearic, and Oleic Acids



- C18:0, under typical feeding situations, is the predominant FA available for absorption by the dairy cow (due to BH)
- Represent the majority of FA in milk fat and adipose tissue
- Predominant FA in the 3 main categories of dietary FA supplements

Recent Focus on Palmitic, Stearic, and Oleic Acids



- All three FA are important for dairy cow metabolism
- Is there an "ideal" ratio among C16:0, C18:0, and C18:1 to optimize their utilization
- Interactions with other dietary and animal factors

3 Major Categories of FA Supplements Available

Fatty Acid, g/100 g	Ca-salt PFAD	Saturated free FA Supplements	
		Mix	C16:0-enriched
C14:0	2.0	2.7	1.6
C16:0	51.0	32.8	89.7
C18:0	4.0	51.4	1.0
C18:1 (n-9)	36.0	5.8	5.9
C18:2 (n-6)	7.0	0.8	1.3

- None of these FA supplements were designed with the cow in mind!
- All simply took the 'best' by-product for the respective manufacturing technology

What fatty acid (fat) supplements are you using?

- ○ I do not feed fat supplements
- ○ Ca-salts of palm oil (PFAD)
- ○ Mixed saturated pills
- ○ Palmitc acid-enriched prills
- ○ Others (e.g. talllow/oil seeds/other Ca-salts)

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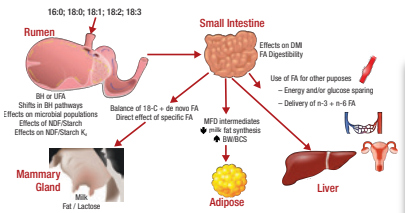
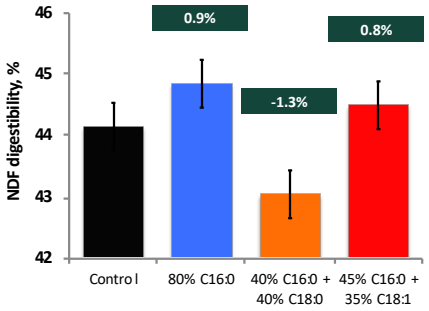


Effect of Dietary FA on NDF and FA Digestibility

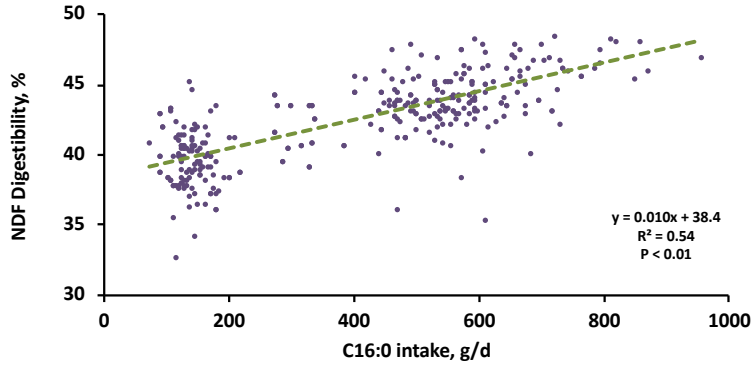
Effect of Altering the FA Profile of Supplemental Fats on Apparent Total Tract NDF Digestibility

- Supplement blends fed at 1.5% DM
- Blends of 3 commercially available FA supplements:
  - C16:0-enriched free FA supplement
  - C16:0 and C18:0 free FA supplement
  - Ca-salt palm FA
- Blended in different ratios to alter content of C16:0, C18:0, and C18:1
- 24 cows in a 4 x 4 Latin square with 21 d periods



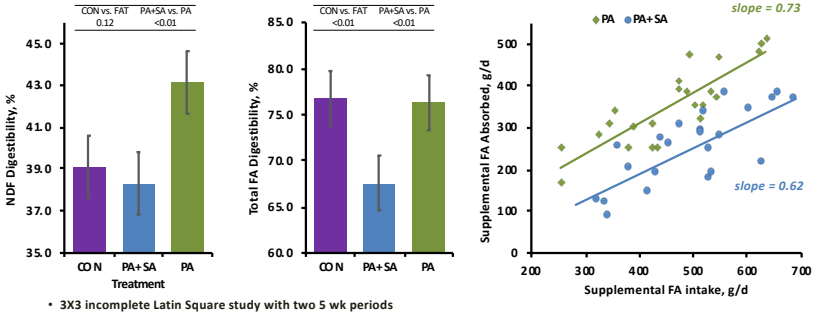
de Souza et al. 2018. J. Dairy Sci. 101:172–185

Effect of C16:0 Intake on ttNDFd



de Souza & Lock (ADSA Abstract, 2016)

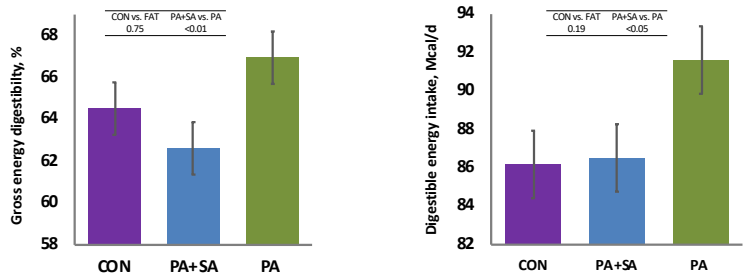
Long Term Effects of Commercially-Available C16:0 and C16:0 + C18:0 Supplements on NDF and FA Digestibility



- 3X3 incomplete Latin Square study with two 5 wk periods
- CON: Control diet (no supplemental fat)
- PA+SA: Control supplemented with 1.5% DM C16:0 and C18:0 FA supplement (33% C16:0; 53% C18:0; 5% C18:1)
- PA: Control supplemented with 1.5% DM C16:0 FA supplement (84% C16:0; 4% C18:0; 9% C18:1)

Western, de Souza, & Lock (ADSA 2018)

Long Term Effects of Commercially-Available C16:0 and C16:0 + C18:0 Supplements on GE Digestibility and DE Intake



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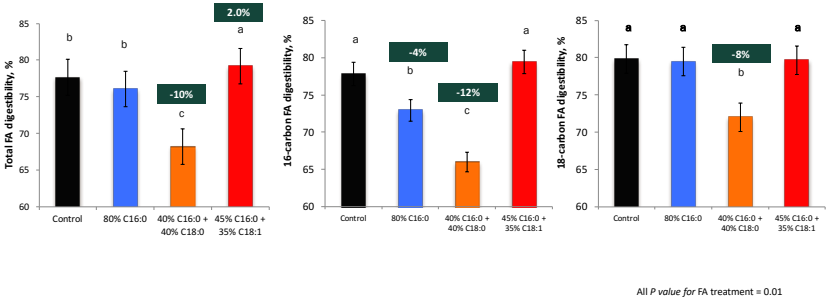
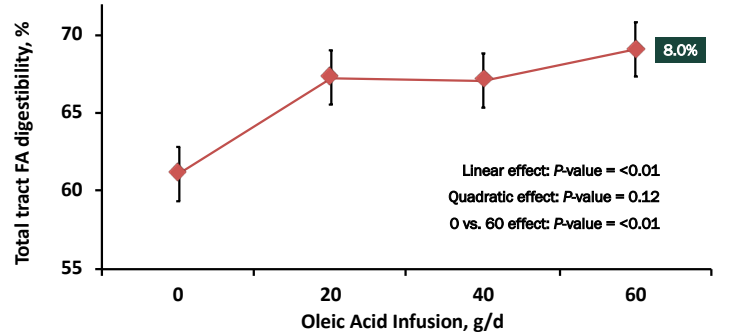
Western, de Souza, & Lock (ADSA 2018)

Effect of Altering the FA Profile of Supplemental Fats on Apparent Total Tract FA Digestibility

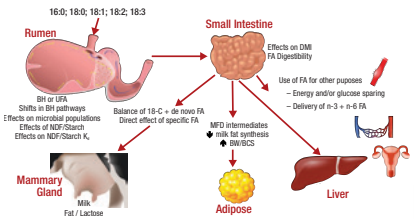


de Souza et al. 2018. J. Dairy Sci. 101:172–185

Abomasal Infusion of Oleic Acid Improves Total Tract Fatty Acid Digestibility

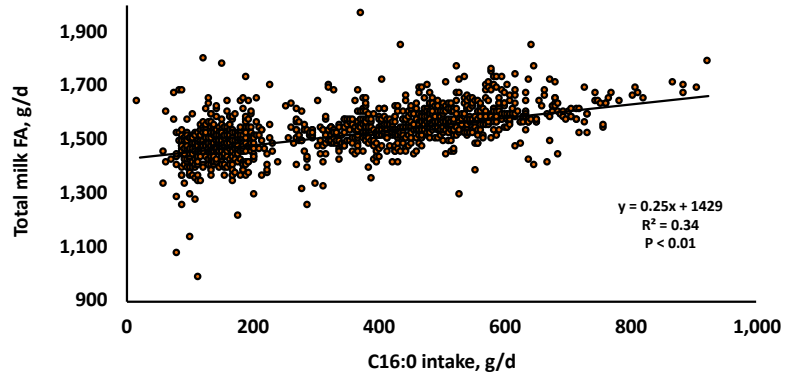


Prom et al. (ADSA Abstract, 2018)



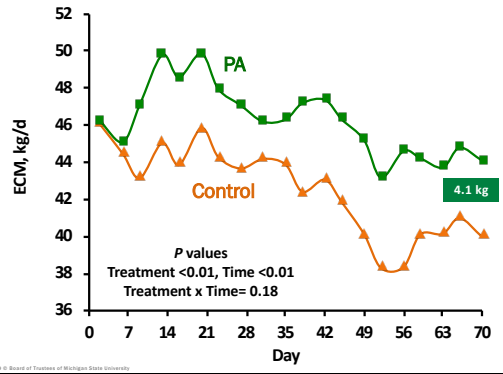
Effect of Dietary FA on Milk Production and Energy Partitioning

Relationship Between C16:0 Intake and Milk Fat Yield



de Souza & Lock. 2018. TSDNC

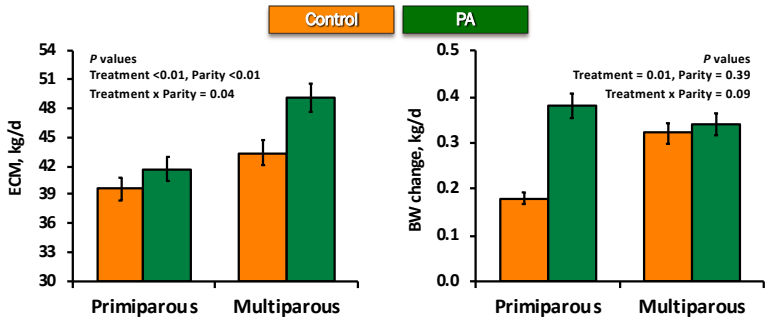
Effect of Long-Term C16:0 Supplementation on ECM Yield



Variable	Control	PA	P value
DMI, kg/d	28.4	30.3	<0.01
Milk, kg/d	45.6	49.4	0.03
ECM, kg/d	43.4	47.5	0.02
Fat, kg/d	1.41	1.56	0.03
Protein, kg/d	1.31	1.40	0.06
Body Weight, kg	689	698	0.45

de Souza & Lock. 2018. J. Dairy Sci. 101: 3044-3056

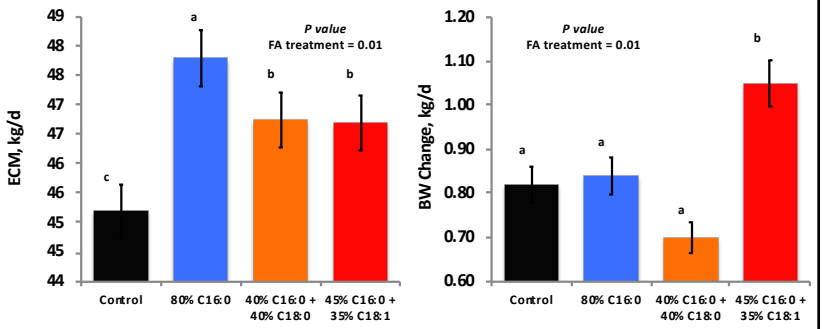
Treatment by Parity Interactions



- PA increased DMI ~ 1.5 kg/d
- ECM increased to a greater extent in multiparous (2.1 vs. 5.7 kg)
- BW increased in primiparous but not multiparous

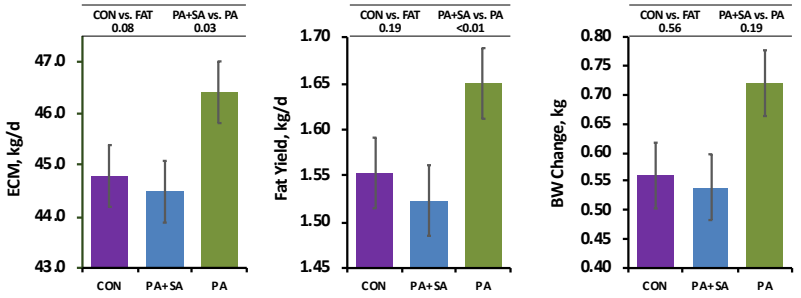
de Souza & Lock. 2018. J. Dairy Sci. 101: 3044-3056

Effect of Altering the FA Profile of Supplemental Fats on ECM and BW



de Souza et al. 2018. J. Dairy Sci. 101:172–185

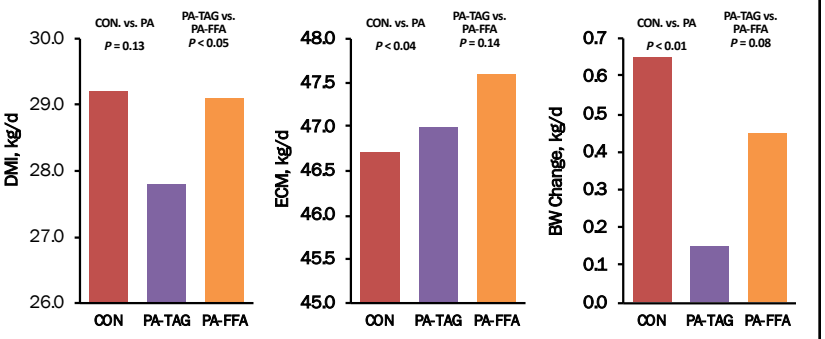
Long Term Effects of Commercially-Available C16:0 and C16:0 + C18:0 Supplements on Production Responses and BW



- 3X3 incomplete Latin Square study with two 5 wk periods
- CON: Control diet (no supplemental fat)
- PA+SA: Control supplemented with 1.5% DM C16:0 and C18:0 FA supplement (33% C16:0; 53% C18:0; 5% C18:1)
- PA: Control supplemented with 1.5% DM C16:0 FA supplement (84% C16:0; 4% C18:0; 9% C18:1)

Western, de Souza, & Lock (ADSA 2018)

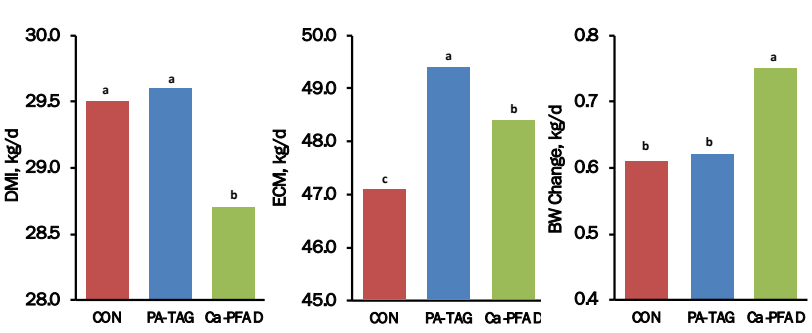
Effect of C16:0 FFA vs. C16:0 TAG



- Supplements fed at 1.5% DM
- 15 cows in a 3 x 3 Latin square with 21 d periods

de Souza & Lock. 2019. J. Dairy Sci. 102: 4155–4164

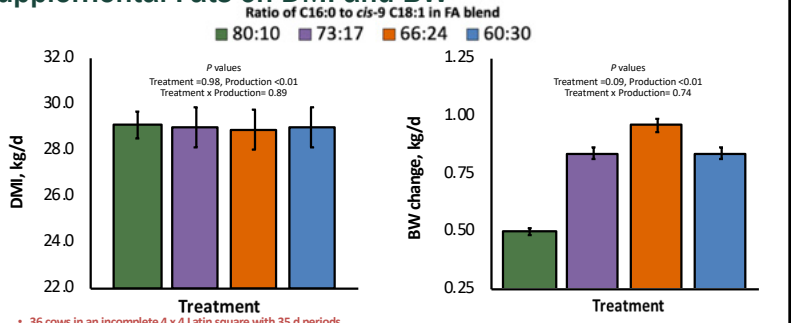
Effect of C16:0 TAG vs. Ca-Salt PFAD



- Supplements fed at 1.5% DM
- 15 cows in a 3 x 3 Latin square with 21 d periods

de Souza & Lock. 2018. J. Dairy Sci. 101: 3110-3117

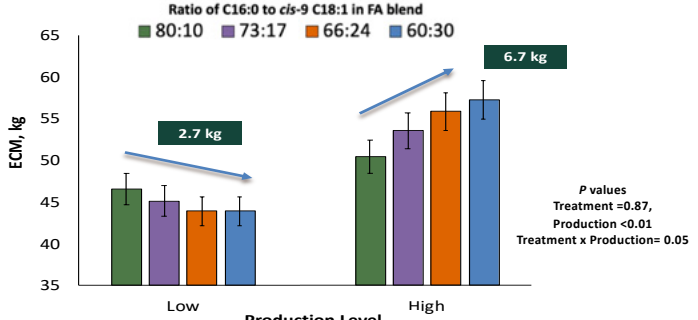
Effect of Altering the Palmitic to Oleic Ratio of Supplemental Fats on DMI and BW



- 36 cows in an incomplete 4 x 4 Latin square with 35 d periods
- Supplements fed at 1.5% DM
- Blends made using combinations of commercially available C16:0-enriched and Ca-salts palm oil supplements

de Souza & Lock (ADSA Abstract 2017)

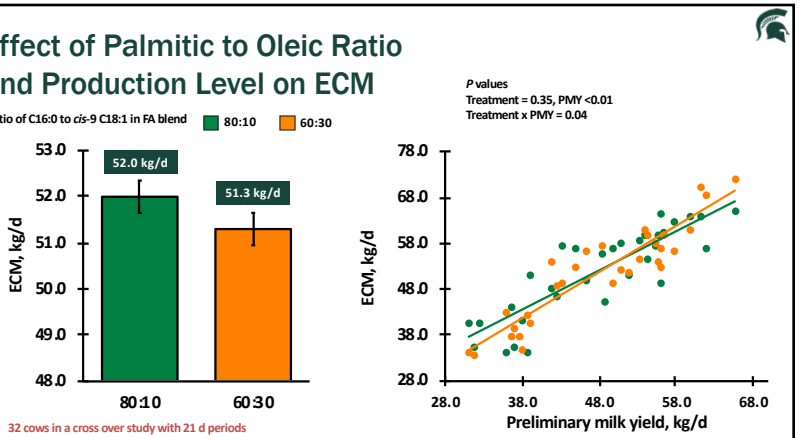
Treatment X Production Level Interactions



- 36 cows in an incomplete 4 x 4 Latin square with 35 d periods
- Supplements fed at 1.5% DM
- Blends made using combinations of commercially available C16:0-enriched and Ca-salts palm oil supplements

de Souza & Lock (ADSA Abstract 2017)

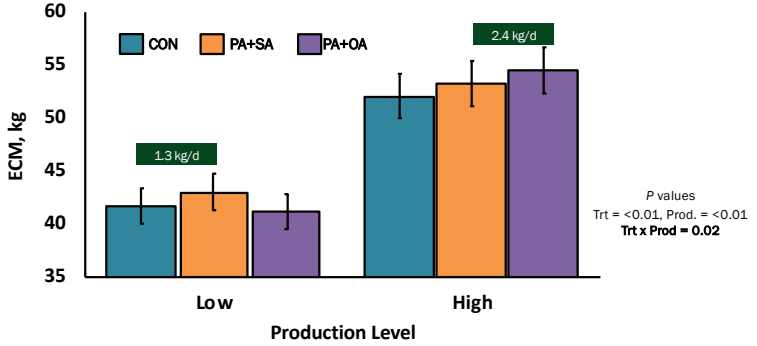
Effect of Palmitic to Oleic Ratio and Production Level on ECM



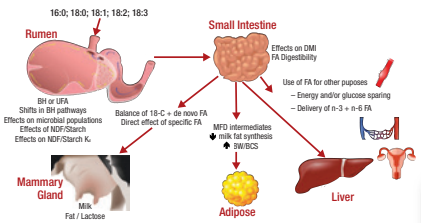
- 32 cows in a cross over study with 21 d periods
- Supplements fed at 1.5% DM; blends made using combinations of commercially available C16:0-enriched and Ca-salts palm oil supplements

Western, de Souza & Lock (ADSA Abstract 2018)

Effect of Palmitic Acid-Enriched Supplements Containing Stearic or Oleic Acid



Burch et al. (ADSA Abstract 2019)



Fatty Acid Supplementation to Early Lactation Cows?

Fat supplementation to early lactation cows will?

- Decrease feed intake
- Reduce body weight loss
- Improve milk production
- All of the above
- It depends

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Fatty Acid Supplementation to Early Lactation Cows?

dogma

dog·ma [dawg-muh, dog-]
noun, plural dog·mas
Prescribed doctrine proclaimed as unquestionably true by a particular group.

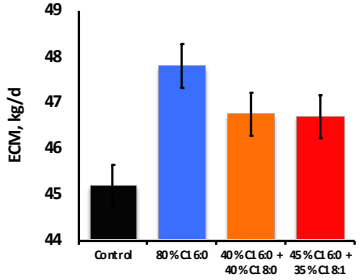
Feeding Strategies for Supplemental Fat

R. R. Grummer
University of Wisconsin
Madison, WI

Grummer. 1992. Large Dairy Herd Management, 2nd Edition

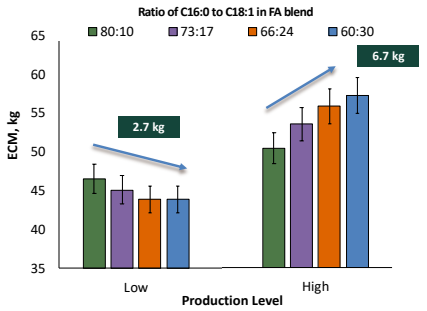
- Should not feed supplemental FA to cows in negative energy balance
- Already too much circulating FA
- When Should Fat Feeding Begin?
  - Ideally, fat probably should be left out of the diet immediately postpartum
  - Numerous trials have indicated that there was little benefit from feeding fat during the first 5 to 7 wk postpartum
  - The lack of early lactation response seems to be related to depression in feed intake which offsets any advantage that may be gained by increasing energy density of the diet

Effect of Palmitic, Stearic, and Oleic Acids in Post Peak Cows



de Souza et al. 2018. J. Dairy Sci. 101:172–185

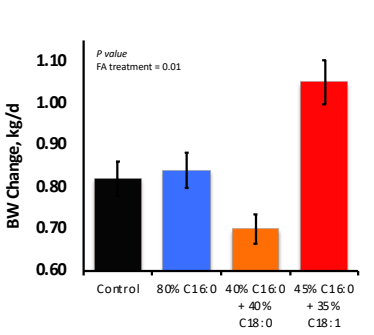
P value
FA treatment = 0.01



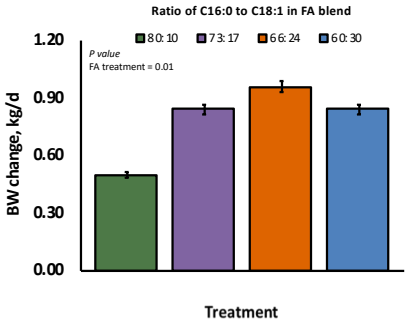
de Souza & Lock (ADSA Abstract 2017)

P values
Treatment =0.87, Production <0.01
Treatment x Production= 0.05

Effect of Palmitic, Stearic, and Oleic Acids in Post Peak Cows



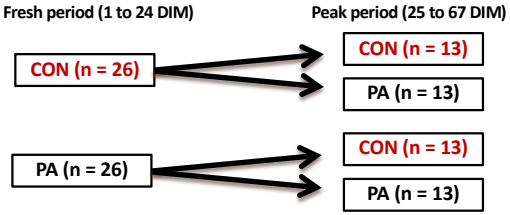
de Souza et al. 2018. J. Dairy Sci. 101:172–185



de Souza & Lock (ADSA Abstract 2017)

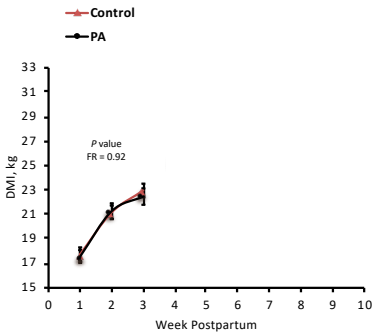
C16:0 Supplementation to Early Lactation Cows?

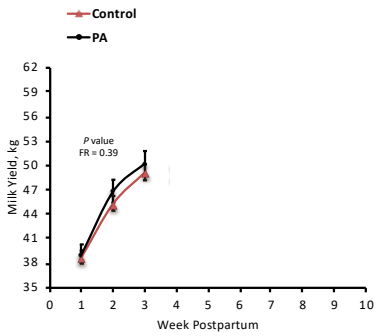
- C16:0 responses have only been evaluated in post peak cows
- Concern regarding:
  - Negative energy balance
  - Reduced DMI of cows in early lactation
  - Increased risk of metabolic disorders



- PA fed at 1.5% DM
- 52 multiparous Holstein cows
- Block design; assigned by parity, 305ME, and BCS

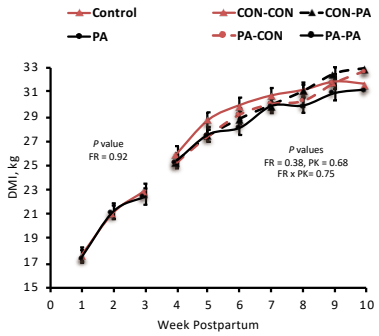
Effect of Supplemental C16:0 on DMI and Milk Yield

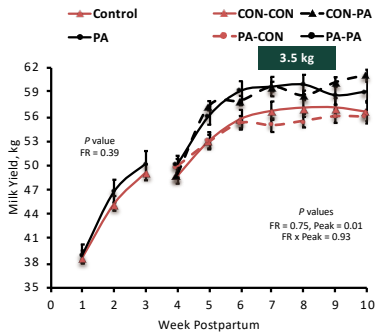




de Souza & Lock. 2019. J. Dairy Sci. (in press)

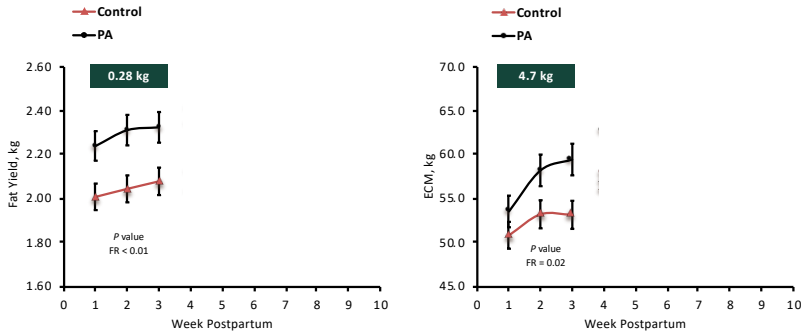
Effect of Supplemental C16:0 on DMI and Milk Yield





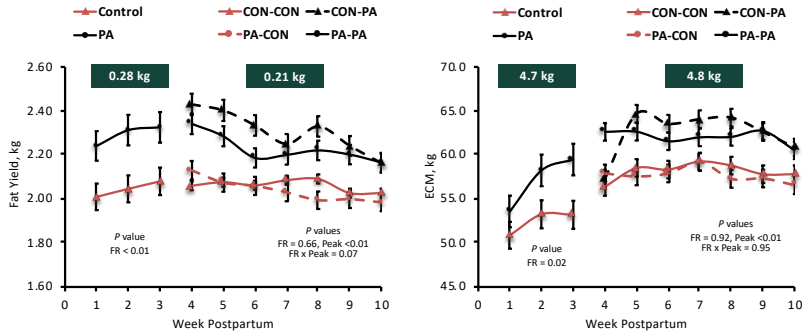
de Souza & Lock. 2019. J. Dairy Sci. (in press)

Effect of Supplemental C16:0 on Yield of Fat and ECM



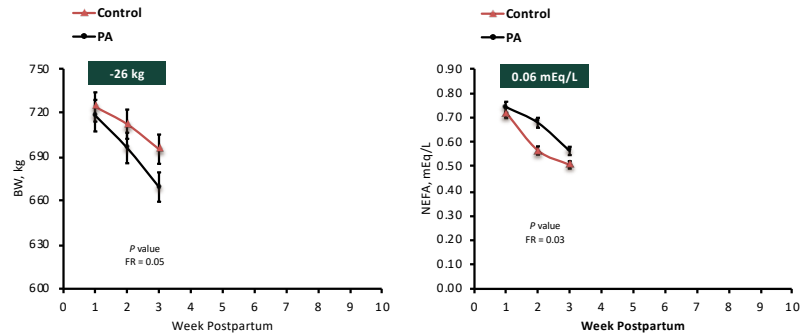
de Souza & Lock. 2019. J. Dairy Sci. (in press)

Effect of Supplemental C16:0 on Yield of Fat and ECM



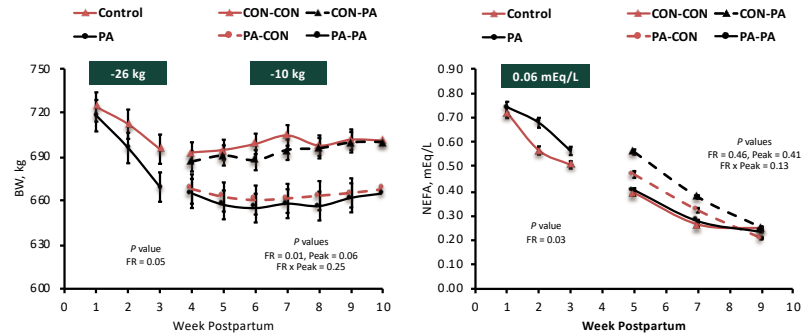
de Souza & Lock. 2019. J. Dairy Sci. (in press)

Effect of Supplemental C16:0 on Body Weight and NEFA



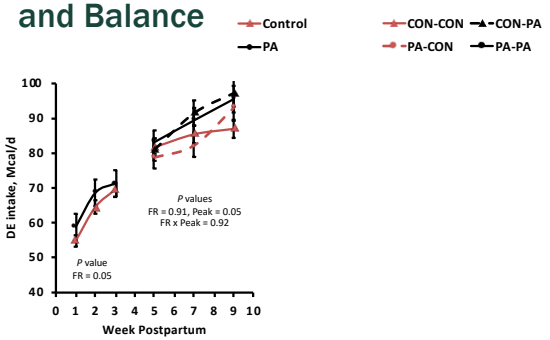
de Souza & Lock. 2019. J. Dairy Sci. (in press)

Effect of Supplemental C16:0 on Body Weight and NEFA



de Souza & Lock. 2019. J. Dairy Sci. (in press)

Effect of Supplemental C16:0 on Energy Intake and Balance

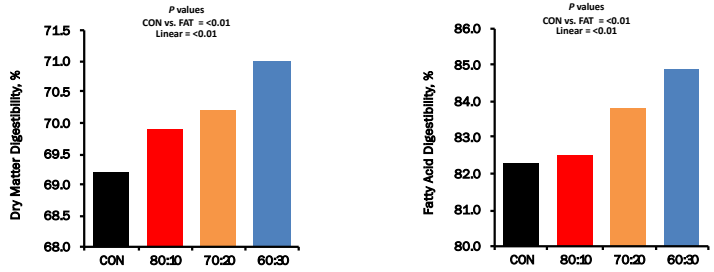


de Souza et al. 2019. J. Dairy Sci. (in press)

Summary

- C16:0 increased NDF digestibility
- C16:0 increased ECM and did not affect DMI in both fresh and peak periods
- C16:0 supplementation induced greater BW loss and increased markers of lipolysis when fed in the fresh period
- For production responses no interaction between treatments and feeding period were observed

Effect of Altering the Palmitic to Oleic Acid Ratio of Supplemental Fats to Fresh Cows



- CON: Control diet (no supplemental fat)
- FA supplement blends fed at 1.5% DM
- Supplemental fat blends fed from calving for first 3 wk of lactation

de Souza, Prom, & Lock (ADSA 2019)

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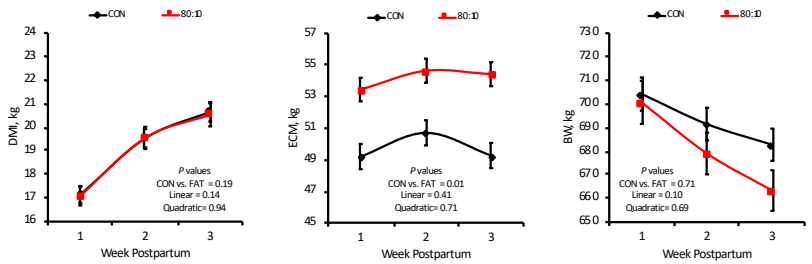

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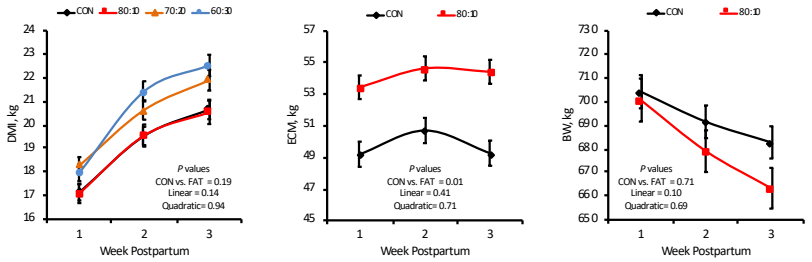

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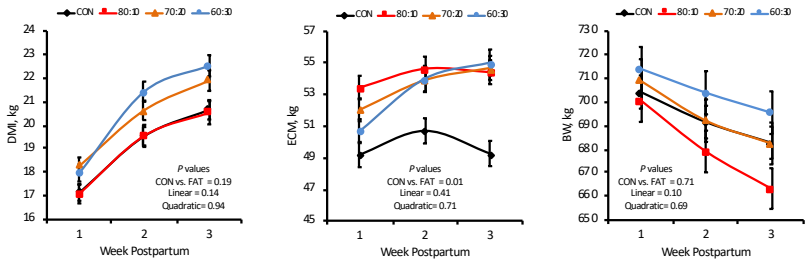

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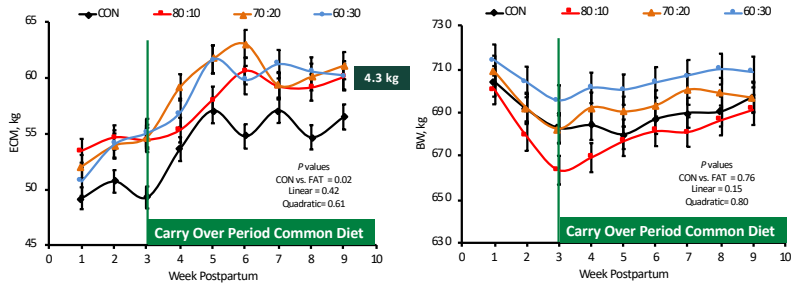

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de Souza, St-Pierre, & Lock (ADSA 2018)

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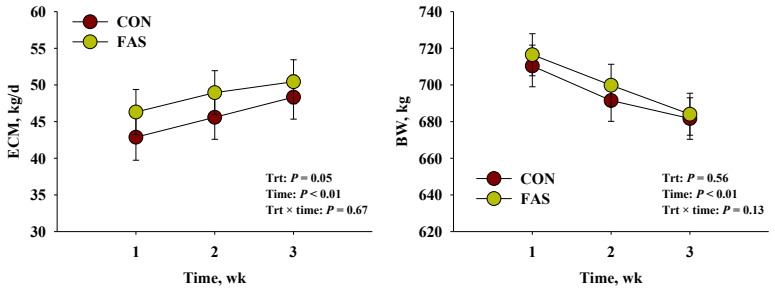
Summary

- Feeding FA supplements containing C16:0 and C18:1 **increased** DM, NDF, and FA digestibility, energy intake, milk yield, and ECM compared with a non-fat control diet
- Increasing C18:1 in the FA supplement **increased** DM, NDF, and FA digestibility, reduced plasma NEFA and BW and BCS losses, and tended to increase DMI and plasma insulin
- The yield of milk and milk components, 3.5% FCM, and ECM were **higher** during the carryover period for cows that received FA-supplemented diets compared with CON during early postpartum

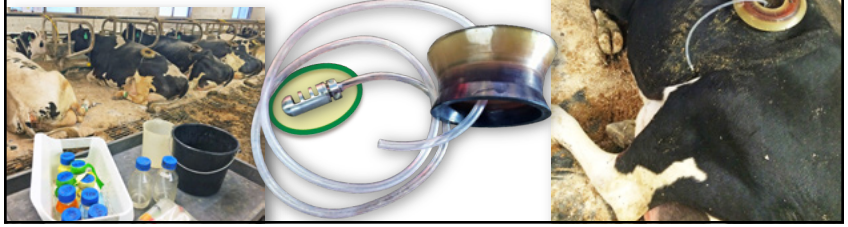
Effect of a Palmitic (60%) and Oleic Acid (30%) Supplement in Fresh Cows (d 1-24)



Pineda, Newbold, & Lock, unpublished

Abomasal Infusion of Oleic Acid in Fresh Cows

- Oleic acid (60 g/d) abomasally infused 4x/d
- Infusions from 1 to 15 DIM
- Adipose tissue (flank) sampled d –14, 6, and 12
- Glucose tolerance test d 15



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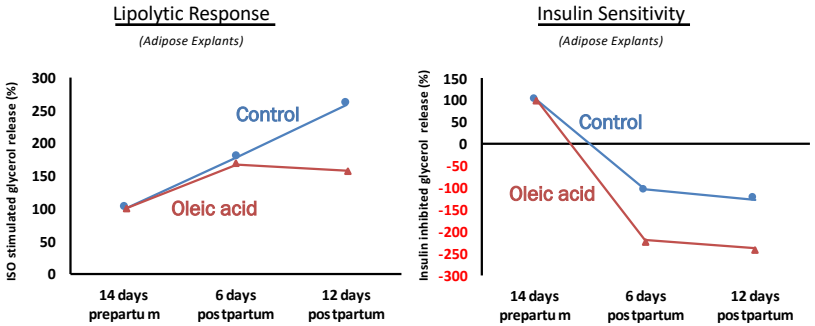

Results suggest that oleic acid supplementation immediately postpartum may reduce lipolytic responses and improves insulin sensitivity of AT in early lactation dairy cows

Contreras & Lock Labs, unpublished

Caloric vs. Non-Caloric Effects of Fatty Acids

Effect of specific fatty acids:

- Yield of milk and milk components
- Maintenance of body condition
- Nutrient digestion
- Nutrient partitioning
- Reproduction
- Health

A BAG OF FAT IS NOT JUST A BAG OF FAT!

FA profile of a fat supplement is the first factor in determining the response to it

How to Make an Informed Decision on Whether to Feed FA Supplements to Dairy Cows?

- Identify what you are trying to achieve, then design your nutritional program (including FA supplementation) around those objectives
- Evaluate the effects of individual FA and commercial FA supplements:
  - Production performance:
    - × Cows at different stages of lactation/levels of milk production
    - × Different diets
  - Tangible factors not measured daily in the tank
    - × BW/BCS/Energy Balance
    - × Reproduction

Economics of the marginal return
(in milk, milk components, health and reproduction)
should drive the decision and be continually evaluated/considered

Our understanding of FA digestion and metabolism in dairy cows has advanced significantly in the last few decades

Presented research focusing on specific FA and how dairy cows respond differently to combinations of FA

Important to consider possible effects of FA
- in the rumen (BH/MFD/NDFd)
- in the small intestine (DMI/digestibility)
- in the mammary gland (increased incorporation/substitution)
- and energy partitioning between tissues

Digestibility appears to be a good indicator of inclusion or not of a FA in a supplement, assuming that this source of FA does not markedly affect DMI

Use of supplemental FA in the fresh period should be considered; new research suggests that FA supplementation increases performance in fresh cows

Profile of supplemental FA key in determining production responses and energy partitioning
1. C16:0 drives increases in milk fat yield and ECM partially due to a decrease in BW
2. C16:0 and C18:1 drives increases in milk yield and ECM without changing BW loss compared to non-supplemental diet
3. Feeding FA supplements in the fresh period has carryover effects on early lactation

Opportunity and challenge will be to continue to improve our understanding of how and which FA affect nutrient digestion, energy partitioning, and milk synthesis in lactating dairy cows, applying this knowledge in the feeding and management of todays high producing dairy cows

Recommendation:
consider use of FA supplements containing C16:0 and C18:1

Acknowledgements

M-AAA Michigan Alliance for Animal Agriculture
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VOLAC WILMAR FEED INGREDIENTS
ARM & HAMMER Animal Nutrition
GLOBAL AGRI-TRADE CORPORATION
EFI
VITA PLUS
USDA United States Department of Agriculture National Institute of Food and Agriculture
NutriLinx Bringing new ideas to animal nutrition LLC
Berg+Schmidt Functional Lipids

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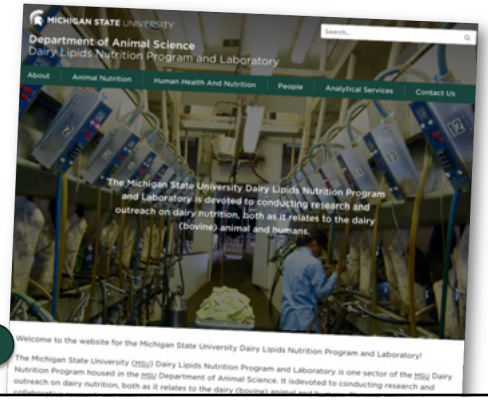

http://dairynutrition.msu.edu

Question from Bruce Mackie, United Kingdom

Given that many C16 supplemental fats are derived from palm oil, a scarce resource from rain forest habitats, what are some home grown/temperate climate alternatives?

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Question from Mohamed W, Egypt

What impact does the stage of forage harvesting have on fatty acid content in silage and hay growing in hot weather?

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Question from Al K, Missouri

Why do high palmitic fatty acid supplements consistently decrease dry matter intake?

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UPCOMING WEBINARS

October 14, 2019
Employee training impacts on animal welfare
Presented by Robert Hagevoort, D.V.M.

November 11, 2019
A feed and forage outlook
Presented by Mike Hutjens, University of Illinois and Mike Rankin, Hay & Forage Grower Magazine

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