Variation in Feed Lipid Composition and Its Impact on Cow Performance

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Variation in Feed Lipid Composition and Its Impact on Cow Performance
Class Objectives

- Highlight why we should move away from ether extract and measure FA conc. & profile
- Emphasize the considerable variation in FA conc. & profile of fermented feeds, grains, and byproducts
- Demonstrate why this may be important with respect to diet formulation
- Highlight possible effects of free vs. esterified FA in feeds and possible impact(s) on rumen function and animal performance

Variation in Feed Lipid Composition and Its Impact on Cow Performance
Key Questions

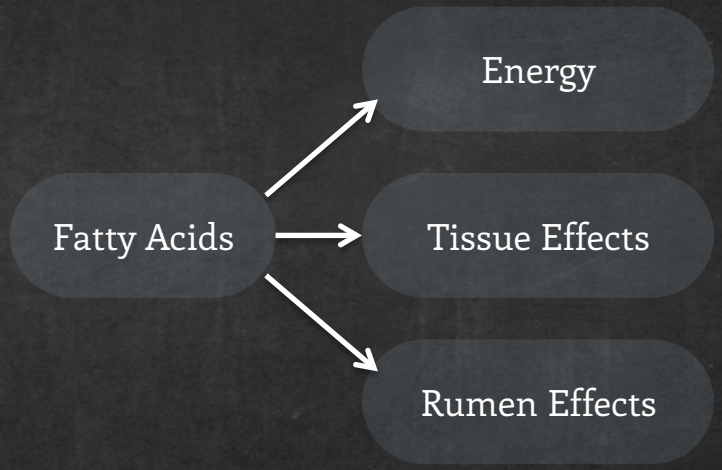
- Do we accept book values for NDF etc?
- Is there a good equation/relationship to estimate FA conc. based on ether extract analysis?
- Does total FA conc. change within feeds?
- Does the FA profile of feeds also change?
- Does the form that FA are in change in feeds?

Variation in Feed Lipid Composition and Its Impact on Cow Performance

Compounds Extracted During Ether Extraction

Lipids

- ❑ Nonglycerol-based
  - Waxes, Alkanes
- ❑ Glycerol-based
  - Simple
  - Compound



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Content and Composition of Ether Extract from Forage Leaves

Content	% DM	% Ether Extract
Ether Extract	5.3	100
Fatty Acids	2.3	43
Wax	0.9	17
Chlorophyll	0.2	4
Galactose	0.4	8
Other unsaponifiable	1.0	19

Adapted from Palmquist & Jenkins, 1980

Ether extract (EE) is most common

- Forages < 50% EE=FA
- Concentrates ~ 80%=FA

NRC (2001)

- Total FA=EE - 1

Total FA

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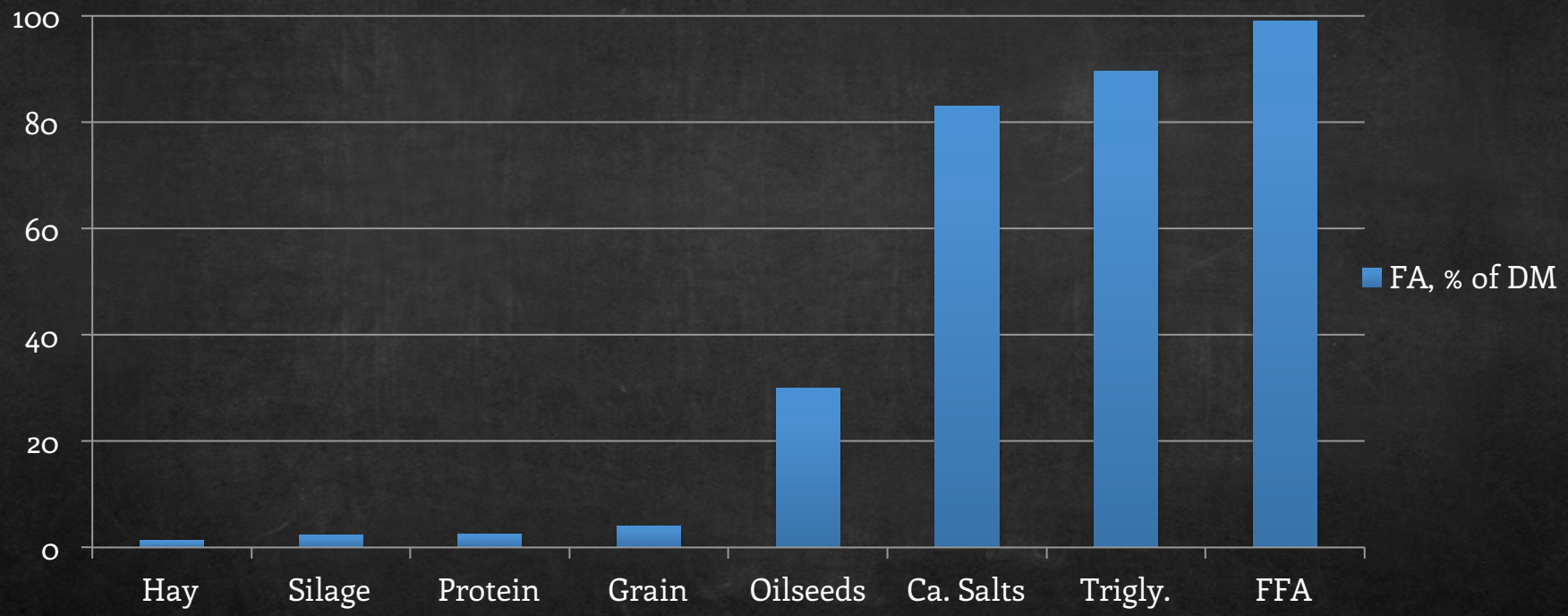
Fatty Acid Content of Feed Ingredients



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Fatty Acids in Feeds – Vast Majority of Fatty Acids in the Diet are MUFA & PUFA

Feedstuff (% FAME)	14:0	16:0	16:1	18:0	18:1	18:2	18:3
Pasture (Grass)	1	16	2	2	3	13	61
Grass Silage	<1	17	2	2	4	24	50
Alfalfa Hay	1	25	2	4	3	18	37
Corn Silage	<1	18	<1	2	19	48	8
Distiller's Grain	<1	18	<1	2	25	56	2
Soybean Meal	<1	12	<1	4	18	55	10
Beef Tallow	3	25	6	18	39	5	<1
Corn Oil	-	11	-	2	27	59	1
Soybean Oil	2	11	<1	4	23	54	8
Calcium Salts	<1	51	-	4	36	7	-

Source: CPM Dairy

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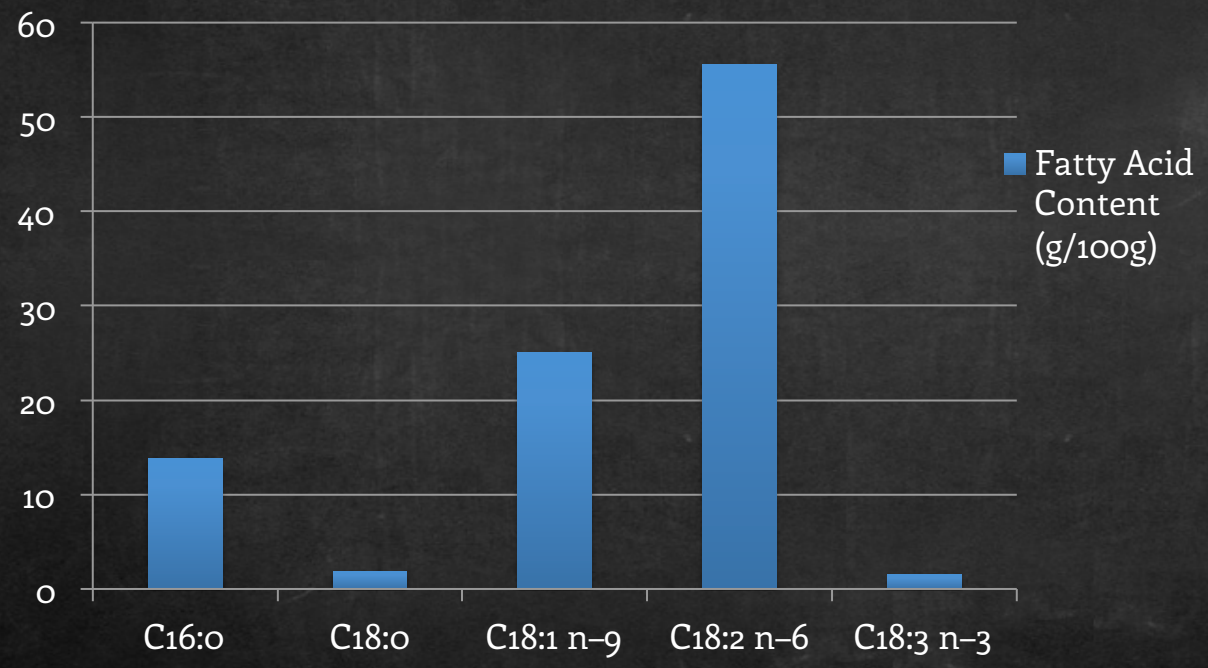
Dried Distiller's Grains (2008 Analysis)



- Analysis of 20 samples (from CVAS)
- Total FA content ranged from 10% to 18% DM
- Little variation in FA profile

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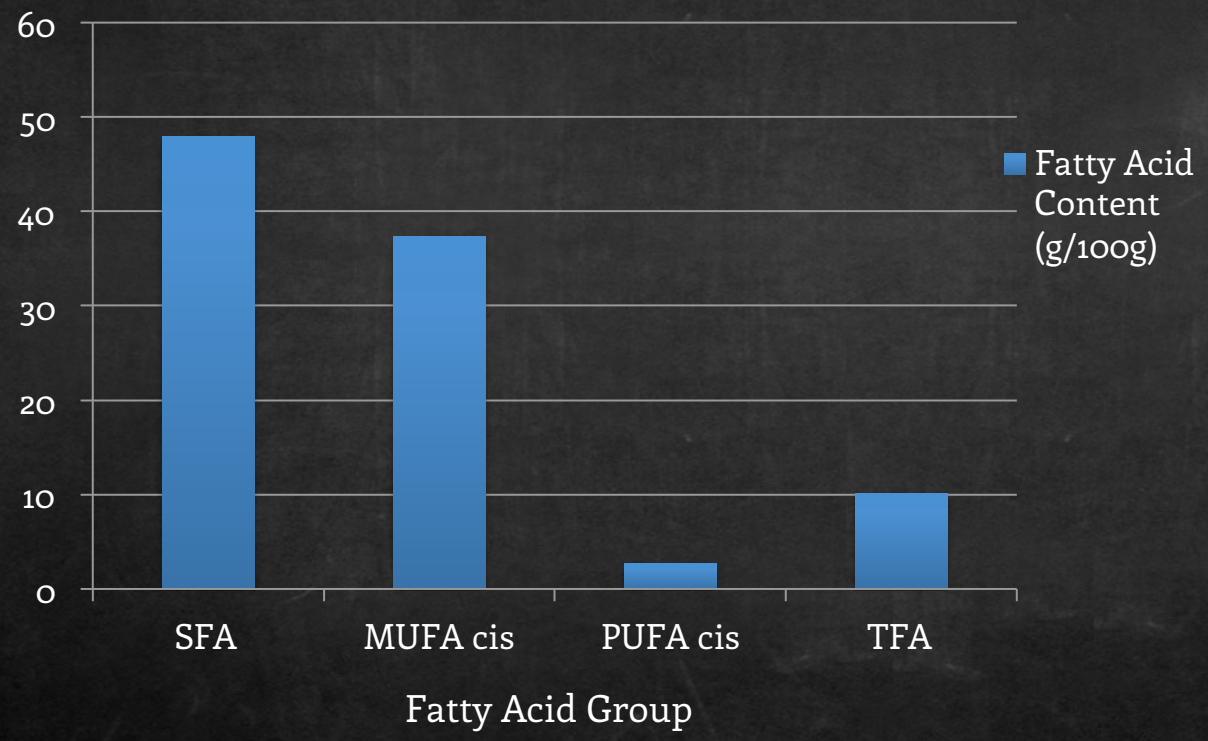
Tallow FA Profile



- > 60 individual FA identified (+ more unknowns)
- Many in small quantities
- (Recently saw some 'tallow' w/ 10-16% 18:2)

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FA in Forages

FA, % DM	Grass Silage	Corn Silage
Mean	1.5	1.6
Minimum	0.6	0.9
Maximum	2.8	3.4

Animal Feed Science and Technology, 2012. 174:36.

Pasture	Grazed	Initial FA % DM	Final FA % DM
Rye	Nov–Mar	6.8	4.7
Annual Ryegrass	Mar–June	4.5	1.8

Freeman-Pounders et al. 2009. Forage and Grazinglands. doi: 10.1094/FG-2009-0130-01-BR.

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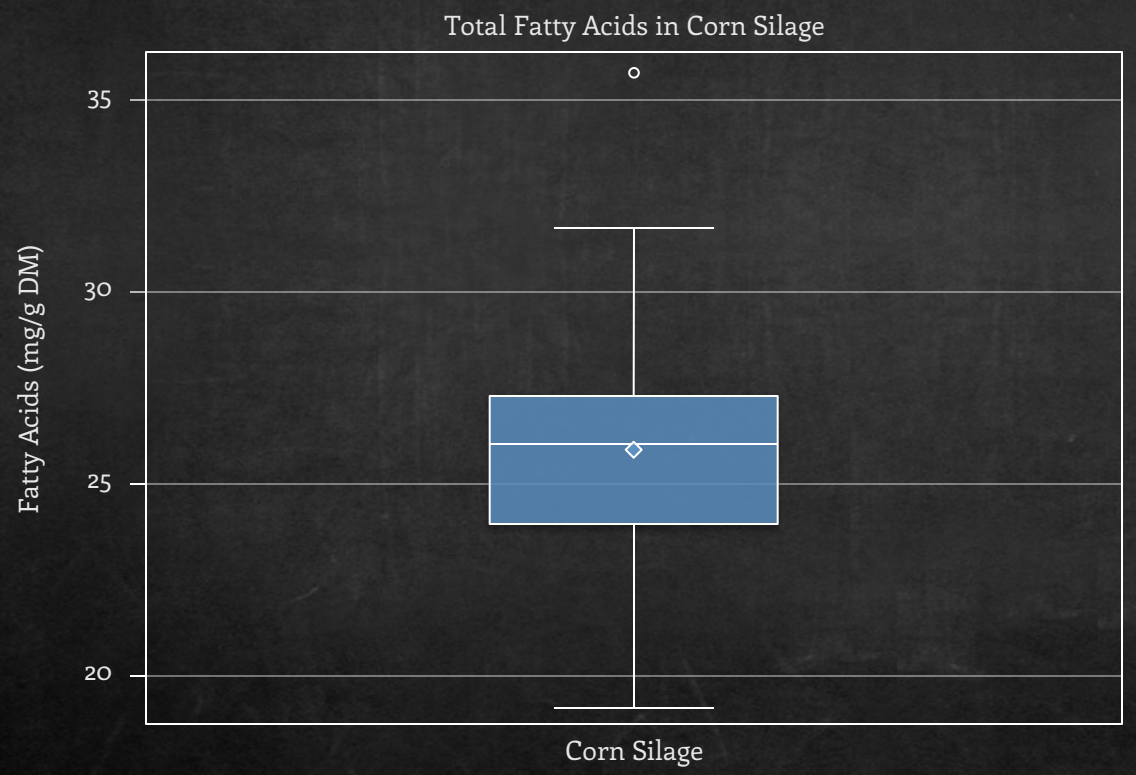
FA Analysis of 2011 Corn Silage Samples in MI (n=45)



- Total FA conc. of corn silage samples ~ 1.8 to 3.2% DM
- Variation in FA profile minimal compared with variation in total FA conc.

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	DM, lb.	FA, %DM	FA, lb.	FA Cont. %
Wheat Straw	2.50	0.6	0.02	1
Corn Silage	15.00	2.2	0.33	20
Corn Silage	5.00	2.2	0.11	7
Haylage	6.25	3.5	0.22	13
Cottonseed w/lint	3.00	18.3	0.55	34
Soybean Hulls	4.00	1.7	0.07	4
Corn Grain (HM)	8.50	3.3	0.28	17
Soybean Meal	8.55	0.1	0.01	1
Soy Plus	1.25	0.1	0.00	0
Limestone	0.37	0	0.00	0
Min/Vit	1.12	3.9	0.04	3
Sodium Bicarb	0.42	0	0.00	0

	FA, %DM	FA lb/d
Current	2.50	0.6
High FA Corn Silage	3.26	1.82
Low FA Corn Silage	2.76	1.54
High FA Corn Silage, Cottonseed & HMC	3.75	2.10

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Changes in FA During Storage & Fermentation

- Orchardgrass harvested at early head stage and sun-cured.
- Drying effects
  - Increase FFA at expense of PL
  - Increased PUFA at expense of oleic and saturated

Yang and Fujita, 1997. Grassland Science 42:289.

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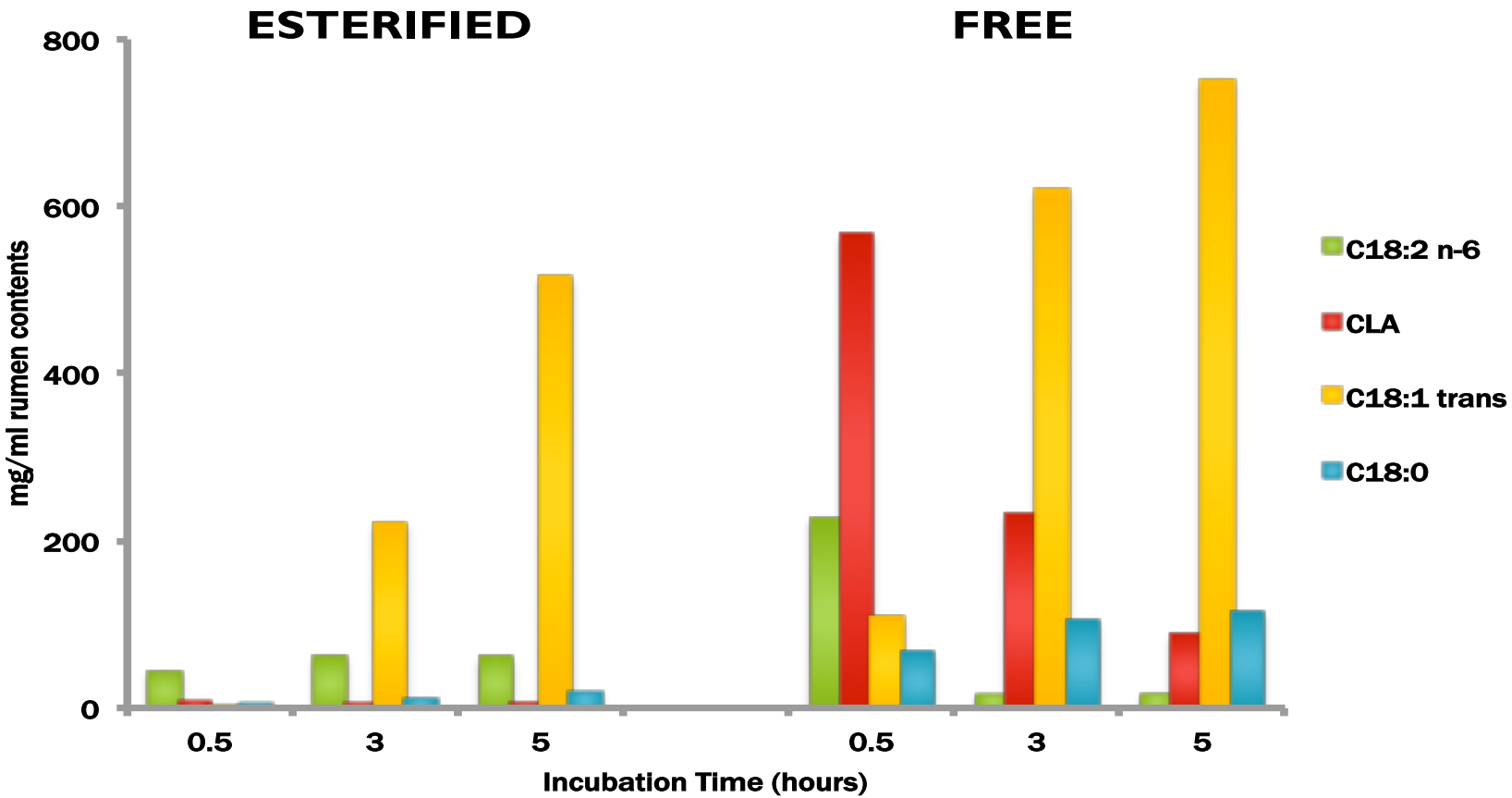
Effect of Ensiling on Free FA Conc.

FFA, % of Total Lipid			
	Fresh	Ensiled	Reference
Ryegrass	2	27–73	Elsgersma et. al. 2003
Timothy	15	56	Vanhatalo et. Al. 2007
Red Clover	8	45	Vanhatalo et. Al. 2007

Plant lipases release free FA after cutting (Thomas, 1986) or during ensiling. (Chow et al., 2004)

The effect of esterified or free linoleic acid on the extent of hydrogenation *in vitro* by sheep rumen contents at 0.5, 3 and 5 hours (Noble *et al*., 1974)



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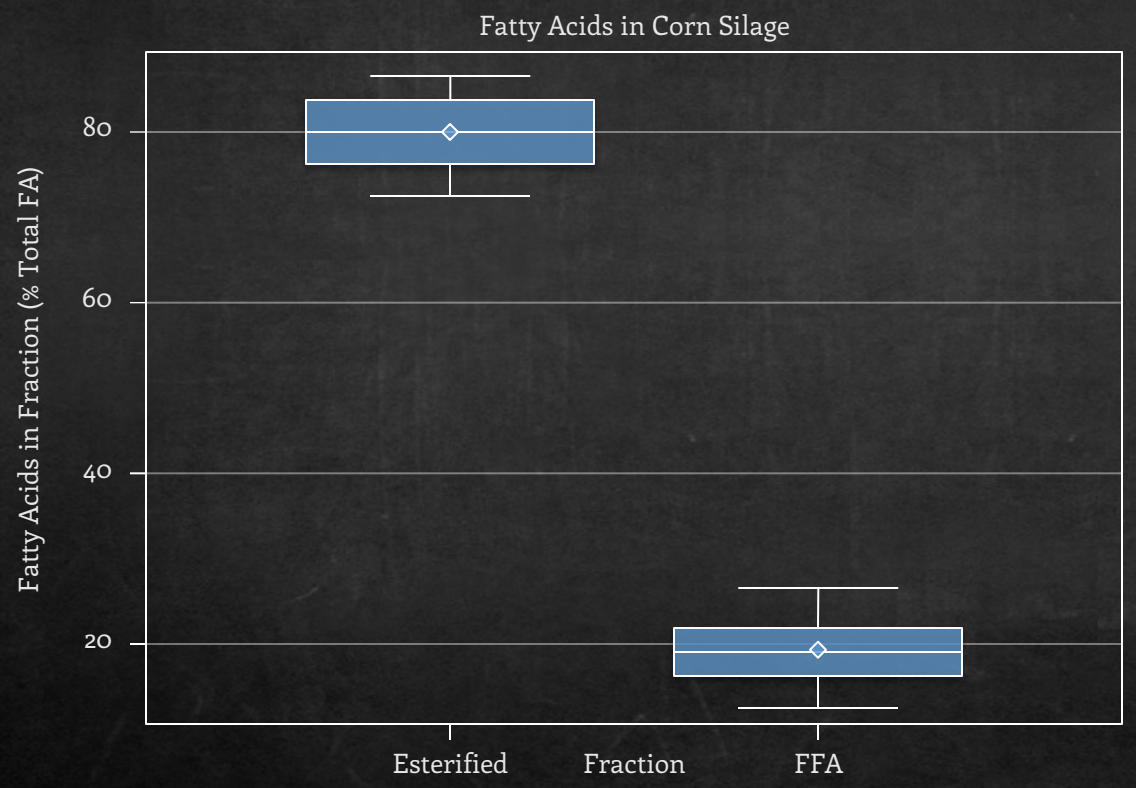
FA Analysis of 2011 Corn Silage Samples in MI (n=45)



- Significant proportion of FA in corn silage are in the form of free FA (~ 15–30%)
- Modest differences in the FA profile of esterified and FFA fractions
- 2 to 3-fold higher conc. (% basis) of C18:3 n-3 in free FA fraction

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Percentage of C18:3 in Free FA as DM Varies

% DM	Ryegrass Silage	Red Clover Silage	White Clover Silage
30	57.3	58.1	59.6
40	33.8	61.4	57.2
50	29.1	60.8	61.0

From Van Ranst et. Al. 2008. Animal Feed Science and Technology. 150:62–74.

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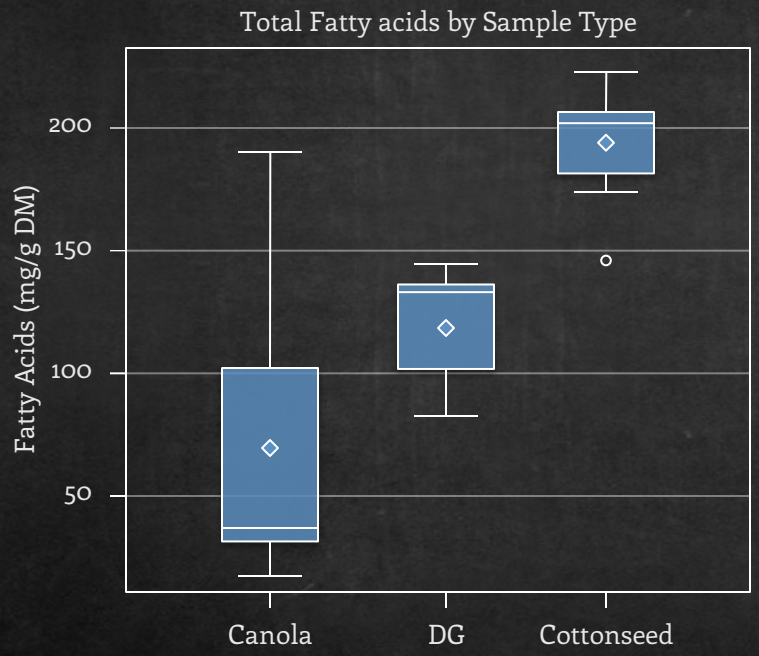
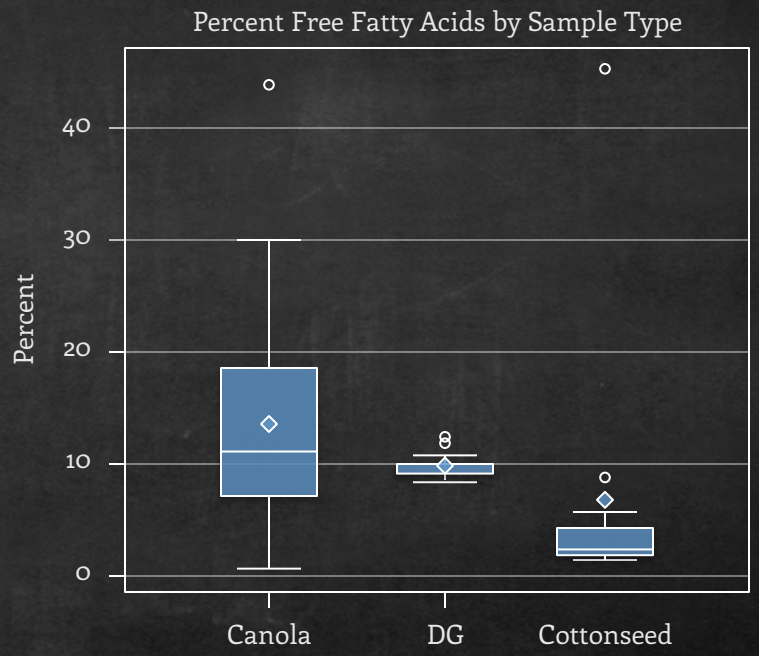
FA Analysis of By-Products





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Effect of Diets Containing Whole Cottonseed (WCS) with Increasing Concentrations of FFA in the Oil

Item	Control	HFFA1[1]	HFFA2	P-Value
WCS Oil, %	18.4	17.1	15.9	
FFA, % of oil in WCS	6.8	24.1	22.3	
DMI, kg/d	21.6	22.0	23.5	0.07
Milk, kg/d	35.0	34.0	35.1	0.39
Fat, %	4.22[a]	3.64[b]	3.58[b]	0.008
Fat, kg/d	1.38	1.25	1.29	0.11

[a,b] Means in the same row with superscripts differ ($P < 0.01$).
[1] HFFA1 = WCS with 24.1% FFA and normal color; HFFA2 = WCS with 22.3% FFA and discolored. All diets supplemented with 14% cottonseed (DM basis). Control, HFFA1 and HFFA2 contained 18, 17 and 16% oil, respectively.
Cooke et. al., 2007

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Key Points

- Ether extraction includes FA plus other non-lipid compounds
- Considerable variation in total FA conc. of corn silage and other feedstuffs that is not accounted for by book values
- Such changes may impact total FA intake and effect of FA on rumen function and animal performance
- Significant (and variable) proportion of FA in corn silage, distillers grains, and cottonseed is in the form of free FA
- Modest differences in total FA profile and the profile of esterified and FFA fractions
- Limited results support the concept that free FA negatively impact rumen BH to a great extent when compared with esterified FA

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Questions & Answers

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