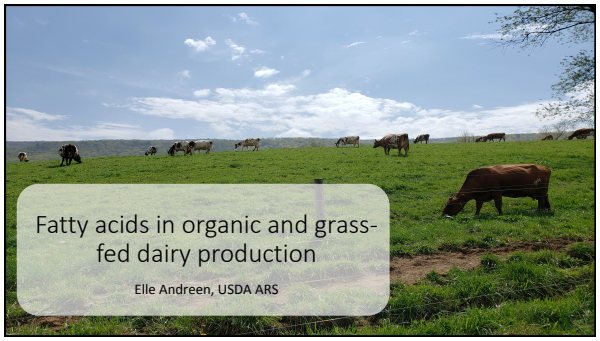


Presenter: Elle Andreen

Support Scientist
Pasture Systems and Watershed Management Unit
University Park, PA

USDA Agricultural Research Service

Working with Dr. Kathy Soder in pasture-based dairy production research: forages and nutrition, management, grazing behavior, multifunctional landscapes, and more

M.S. in Animal Science at Penn State with Kevin Harvatine
- Ruminant nutrition and milk fat

B.S. in Animal Science at Michigan State

The University of Vermont

PennState College of Agricultural Sciences

Outline

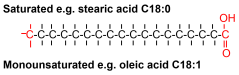
- What are fatty acids? How are they measured/quantified?
- How are fatty acids metabolized into milk fat?
- Which fatty acids are of interest to organic/grass fed production and why?
- What does the research say about fatty acids in organic and grass fed compared to conventional milk?
- What management factors influence milk content of desirable fatty acids?
- Why does this matter to consumers and to dairy farmers?
- Questions and discussion

Introduction: The basics of fatty acids

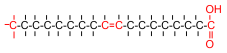
Fatty acids are the 'building blocks of lipids'

The chain length and saturation of each fatty acid determine its physical characteristics and impacts on human/animal health.

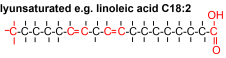
Saturated e.g. stearic acid C18:0



Monounsaturated e.g. oleic acid C18:1



Polyunsaturated e.g. linoleic acid C18:2



Chain length refers to the number of carbons in the carbon chain.

Saturation refers to the number and position of double bonds in the carbon chain.

***Trans* vs *cis* fatty acids**:
Trans and *cis* refer to the position of hydrogens around a double bond. Both occur in nature – it is **artificially** hydrogenated *trans* fats that are very bad for human health.

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Slide partially adapted from K. Harvatine

Introduction: Fatty acids in cow's milk

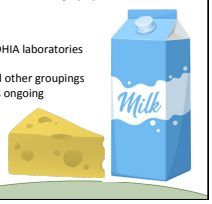
There are a very wide array of fatty acids (FA) present in cow milk – **over 400!**

....But, we only quantify about 40-50 individual FA in dairy research. They can be from 2 to 28 carbons in length and are about 60-70% saturated, the remainder unsaturated.

"Gold standard" for measuring the amounts of individual fatty acids: **gas chromatography.**

New technique: **MIR spectroscopy**

- Largely pioneered by Dr. Dave Barbano of Cornell University
- Similar technology used for milk component and forage testing at DHIA laboratories
- Faster, easier and less expensive
- Currently able to identify portions of saturated/unsaturated fat and other groupings
- Not yet capable of identifying individual long-chain FA – but work is ongoing



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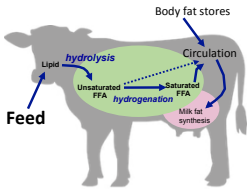
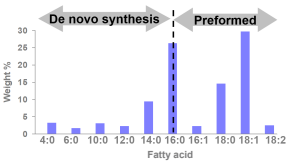
Fatty acid metabolism in the dairy cow starts in the rumen!





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Pasture-based diets contain different fatty acids than conventional diets

Omega 6:
18:2 n-6 – linoleic acid (LA) vegetable oils, grains, ruminant products

Omega 3:
18:3 n-3 – alpha-linolenic acid (ALA) nuts, seeds, plants

20:5 n-3 – Eicopentaenoic (EPA) aquatic sources

22:6 n-3 – Docosahexaenoic (DHA) aquatic sources

	:0	18:0	18:1	18:2, n-6	18:3, n-3
P	6	2	3	13	61
G	7	2	4	24	50
Al	25	4	3	18	37
G	8	2	19	48	8
	8	2	25	56	2
G	1	2	27	59	1
S	2	4	18	55	10
Sc	11	4	23	54	8
	5	18	39	5	<1
G	1	4	36	7	-

S

Both omega 3 and omega 6's are very important fatty acids for human health! Neither is 'good' or 'bad'

Ratio of 6 to 3 should be 4 to 1… most Western diets are more like 10:1

Can pasture-based dairy products help us get more omega 3's?

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CLA's are another fatty acid found in milk

Conjugated linoleic acid (CLA) is found in dairy and meat products

Most common in ruminant products is ***cis-9 trans-11* CLA,** or rumenic acid, shown to be **anti-carcinogenic**

CLA is relatively stable throughout processing and manufacturing

Variable content observed in milk – indicates concentration can be modified by **management**

- CLA observed to increase up to 2x in cows switched to pasture[1]

1: M.L. Kelley et al. 1998. Effect of Intake of Pasture on Concentrations of Conjugated Linoleic Acid in Milk of Lactating Cows. J. Dairy Sci. 81:1630-1636.

Food	Total CLA (mg/g fat)*
Dairy Products	
Homogenized milk	4.5
Butter	6.0
Sour cream	4.6
Plain yogurt	4.8
Ice cream	3.6
Cheddar cheese	3.6
Mozzarella cheese	4.9
Cottage cheese	4.5
Meat	
Fresh ground beef	4.3
Beef round	2.9
Veal	2.7
Lamb	5.6
Pork	0.6
Chicken	0.9
Fish	0.3
Fresh ground turkey	2.5

Source: PSU Extension

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All milk contains healthy fatty acids – and organic and grass fed milk can have higher amounts

Scientists are beginning to recognize that milk and milk fat is healthier than previously thought – multiple large cohort studies and reviews of past research have been published stating that **reduced or full fat dairy consumption is not associated with increased cardiovascular or other health risks.**

Siri-Tarino PW, Sun Q, Hu FB, Krauss RM. 2010. Meta-analysis of prospective cohort studies evaluating the association of saturated fat with cardiovascular disease. **American Journal of Clinical Nutrition.** 91(3):535-546.

German JB, Gibson RG, Krauss RM, et al. 2009. A reappraisal of the impact of dairy foods and milk fat on cardiovascular disease risk. **European Journal of Nutrition**. 48(4):191-203.

de Oliveira Otto MC, Mozaffarian D, Kromhout D, et al. 2012. Dietary intake of saturated fat by food source and incident cardiovascular disease: the Multi-Ethnic Study of Atherosclerosis. **American Journal of Clinical Nutrition**. 96(2):397-404.

We've discussed the biology behind FA in pasture-based milk…

What does the "real world" research say?

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Feeding pasture increases CLA content

A. Siruana and S. Calsamiglia. 2016. Animal Feed Science and Technology 217:13-26.

Meta-analysis of 69 publications with 260 treatment groups, including 19 treatments from feeding fresh pasture:

	Control	Pasture	Ryegrass	Corn	Soy	Sunflower	Linseed	Fish oil	Fish + Veg oil	SEM	P-value
Total fatty acids, g/kg DM	30.0^{d}	23.9^{g}	34.1^{cb}	44.1^{bc}	49.6^{ab}	59.3^{a}	55.2^{ab}	37.1^{cd}	45.5^{bc}	1.78	<0.01
DMI, Kg/d	21.3	19.0	21.2	21.8	20.4	19.6	20.8	21.0	20.9	0.51	<0.01
Milk yield, Kg/d	30.1^{ab}	27.6^{c}	29.6^{bc}	32.4^{a}	30.6^{ab}	28.8^{bc}	29.2^{bc}	31.0^{ab}	31.4^{ab}	0.87	<0.01
Fat, g/kg	36.1^{a}	38.6^{a}	34.2^{ab}	34.4^{ab}	33.2^{b}	33.6^{b}	36.5^{a}	32.2^{b}	31.2^{b}	00.63	<0.01
Fat yield, Kg/d	1.11^{a}	0.94^{ab}	1.04^{ab}	1.13^{a}	1.02^{ab}	0.94^{b}	1.07^{a}	1.03^{ab}	1.03^{ab}	0.039	<0.01
cis-9, trans-11CLA, g/100 g fatty acids	0.61^{c}	1.13^{ab}	0.83^{bc}	0.84^{bc}	1.00^{ab}	1.04^{ab}	0.90^{b}	0.67^{bc}	1.34^{a}	0.044	<0.01
cis-9, trans-11CLA, g/d	5.67^{c}	8.56^{bc}	7.78^{bc}	8.73^{ab}	9.24^{ab}	10.1^{ab}	8.50^{bc}	5.91^{c}	12.4^{a}	0.399	<0.01

CLA concentration in milk fat:

- Nearly 2X greater in pasture treatment compared to control
- Numerically greater than other supplementation methods but not statistically different

Total CLA production (g/day):

- Not different from control or other treatments
- Likely due to lower milk yield and numerically lower milk fat yield

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Concentration of CLA in milk was 1.8x greater, but total CLA production may be limited by milk fat yield

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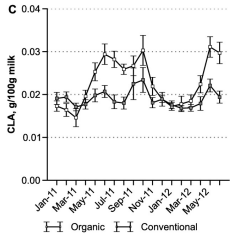
Seasonal variation influences the content of beneficial fatty acids in organic milk

- CLA in organic milk was 55% higher in summer vs winter, conventional was only 12% higher[1]
- Organic 42% higher compared to conventional in summer, **not different from conventional in winter**
- Similar seasonal patterns but smaller variability (20-40% from highest to lower) in omega 3 fatty acids[2]
- Gradual increase during grazing season, abrupt decrease when moved indoors



1: A. Siruana and S. Calsamiglia. 2016. Animal Feed Sci. and Tech. 217:13-26.
2: Benbrook et al. 2018. Food Sci. and Nutr. 6:681-700.

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Retail organic milk in the U.S. contains more ALA and EPA than conventional

Organic Production Enhances Milk Nutritional Quality by Shifting Fatty Acid Composition: A United States–Wide, 18-Month Study
- 14 commercial milk processers in the Northwest (3), California (1), Rocky Mountains (1), Texas, (1), Midwest (2), Mid-Atlantic (2), and Northeast (3)
- One milk sample a month obtained from processed for 18 months, Jan 2011 – June 2012 (220 organic and 164 conventional samples total)

Averages across 12 months:

	% greater in Organic	Organic		Conventional	
		Mean	CV	Mean	CV
Total saturated	3.77%	68.39	5.7%	65.90	4.7%
Total polyunsaturated	25.33%	3.35	12%	3.70	14%
LA	62.50%	2.06	16%	2.76	37%
ALA	20.00%	0.84	35%	0.52	41%
EPA	19.79%	0.10	37%	0.08	25%
CLA		0.74		0.62	

P-values of Organic vs Conventional all < 0.0001

Higher PUFA and n-3 PUFA, conjugated linoleic acid … in organic milk: a systematic literature review and meta-analysis
- Meta-analysis using 89 research publications, with data primarily from Europe

Averages across 89 research publications:

	% greater in Organic	Organic	Conventional
		Mean	Mean
Total saturated	0.76%	67.8	68.3
Total polyunsaturated	12.29%	4.14	3.63
LA	43.1%	0.77	0.438
ALA	33.3%	0.09	0.06
EPA			
CLA	23.0%	0.87	0.67

Benbrook et al. 2013. PLoS One. 8(12):e82429
Srednicka-Tober et al. 2016. Brit. J. Nut. 115:1043-1060.

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Dairy CLA and omega 3 implications for human health

How would switching to pasture-based dairy affect daily intake of CLA and omega 3 FA?

Assuming 40g of dairy fat consumption daily (1 serving whole milk has 8 grams of fat)

CLA:
If CLA increased from 0.60 to 1.1 % of milk fat:
- Total intake from dairy would increase from 0.24 to 0.44 grams per day
- CLA recommendation currently unknown, but research trials conducted with 1 up to 8 g/day

NIH recommended amounts of omega 3 are 1 to 1.5 g/d.

ALA:
If ALA increased from 0.5 to 0.8% of milk fat:
- Total intake from dairy would increase from 0.2 to 0.32 grams per day
- Dairy would account for **20-30% of omega 3 requirement**

EPA
If EPA increased from 0.06 to 0.1% of milk fat:
- Total intake from dairy would increase from 0.024 to 0.04 grams per day
- Dairy would account for **2.6-4% of omega 3 requirement**

Pasture-based milk could ***potentially*** account for 23-34% of daily omega 3 requirements, compared to 15-23% for conventional.

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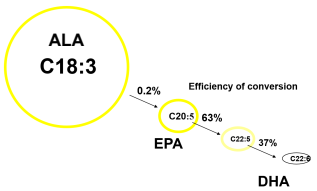
Management factors can influence desirable milk fatty acids

Challenges in maximizing milk content of CLA and omega-3's:
1. Rumen biohydrogenation
2. Low synthesis of EPA/DHA
3. Low transfer of EPA/DHA into milk

Strategies to increase CLA and omega 3's:
1. Increasing pasture/forage intake
2. Supplementation
3. Genetics?



Slide partially adapted from K. Harvatine

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Management strategies to increase desirable milk fatty acids

Increase pasture/forage intake
- Cheap and "built in" – pasture-based has clear advantage here
- Can reduce milk fat and thus total production of healthy FA

Supplementation
- Flax seed[1]
  - Extruded and encapsulated forms are typically most effective, can increase milk CLA ~10-20%
  - Decrease in milk fat often observed, likely due to high UFA content
  - Content of ALA can vary by season and strain
  - Not well-assessed in pasture-based conditions
  - Expensive – how do you determine benefits? Are you being paid for them?
- Fish and unsaturated plant oils
  - Effective in increasing CLA and EPA/DHA
  - Issues with storage, rancidity, palatability, milk fat depression; FA content can vary by species
  - Expensive – probably better off just eating the fish ourselves!

Genetics?
- CLA content is variable between animals under similar management – opportunity for selection
- Holsteins had greater CLA content in three studies with conventional diets and one study with pasture-based diet[2]
- Milk CLA content was found to be low to moderately heritable (0.15)[3]
  - Difficulty in selecting for CLA content due to negative genetic correlation with milk fat, and lack of access to testing for milk CLA

1: U. Moallem. 2018. JDS. 101:8641-8661.
2: T. Ohlsson et al. 2007. Crit. Rev. in Food Sci. and Nutr. 45:6:463-482
3: M. Miele et al. 2009. JDS. 92:1:392-400.

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Fatty acids are a major contributor to consumer perception of pasture-based milk as healthier

Horizon Organic DHA milk – 26 million gallons sold in 2015, with DHA from algal oil – not synthesized by the cow!

4 Things You Need to Know About Grass-Fed Milk

The grass could be greener on the other side of the dairy aisle.

American Grassfed

USDA ORGANIC

REUTERS

Is milk from grass-fed cows more heart-healthy?

npr

Study: Organic Milk Contains More Healthy Fatty Acids

Parents

Is Grass-Fed Milk Actually Healthier?

CERTIFIED GRASS-FED

UNIVERSITY OF MINNESOTA EXTENSION

Grass-fed cows produce healthier milk

Home > Animals and livestock > Dairy > Dairy nutrition > Grass-fed cows produce healthier milk

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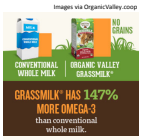
Consumer demand could drive how cooperatives value fatty acids in pasture-based milk

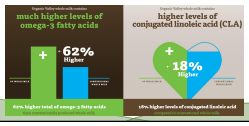
Companies/cooperatives clearly value the content of beneficial fatty acids in milk!

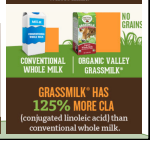
As previously discussed, there is some variation, especially in CLA, between and within sources due to environment and management….

Could cooperatives start placing a premium on milk FA content?
- Reliable, inexpensive testing for individual fatty acids
- Seasonal variation
- Cost of supplements or other management strategies to improve content in indoor season

Images via OrganicValley.coop







Conclusions and takeaways

- Multiple peer-reviewed publications have determined that pasture-based milk contains higher concentrations of beneficial fatty acids
  - ALA: 40-60% greater CLA: up to 2X greater, but variable EPA: 30-40% greater
  - Impact on human health depends on specific FA content of milk and how much milk fat is consumed
- Higher fatty acid content appears to largely due to dietary proportion of pasture and forage – natural, low cost advantage for organic and grass fed dairy compared to conventional
- Management factors can alter content of milk fatty acids, but may currently be unrealistic to implement
  - Biology: ruminal biohydrogenation and poor transfer into milk
  - Quantification: expensive, but improvements being made
  - Cost: supplementation to improve may not yield additional returns
- Fatty acids in pasture-based milk contribute to increased demand for organic and grass fed dairy products

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Thanks!

This webinar was produced as part of USDA NIFA Organic Research and Education Initiative grant no. 2018-02802, titled "**Advancing Grass-Fed Dairy: A Whole Systems Approach to Enhancing Productivity, Quality, and Farm Viability in the U.S.**" (PI Heather Darby, Agronomist and Nutrient Management Specialist, University of Vermont Extension, heather.darby@uvm.edu)

The University of Vermont

USDA NIFA

United States Department of Agriculture
National Institute of Food and Agriculture

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Introduction: Fatty acids in cow's milk

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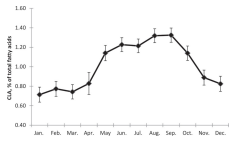

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- A recording will be available in our archive (see below) and on the eOrganic YouTube channel within 1-2 weeks
- Find more archived webinars at http://eorganic.org/node/4942
- Find all eOrganic resources at http://eorganic.org
- Have an organic farming question? Use the eXtension Ask an Expert service at https://ask.extension.org/groups/1668
- Please send your feedback! We will email you a survey about this webinar later today.
- Thank you for coming!