NE SARE Farmer/Grower Grant Final Report

1. Project name and contact information

Title: A longitudinal comparison study of milk nutrient levels among varied farm management systems / FNE05-541

Kathie Arnold
3175 State Route 13
Truxton, NY 13158-3107
607/842-6631
kathieyarnold@gmail.com

2. Goals

The purpose of this SARE grant was to synergize research efforts and fund further nutrient testing of milk samples that were collected for an Organic Farming and Research Foundation (OFRF) study lead by Linda Tikofsky, DVM at Cornell University's Quality Milk Production Services (QMPS).

3. Farm Profile

We have approximately 130 lactating age organic dairy cows and around 120 youngstock on our farm. We have over 700 acres in certified organic production as pasture, haycrop, small grains, corn, and soybeans. In the past year we began selecting and using only sires for breeding our lactating herd that are A2A2 for beta casein and also endeavoring to find sires that carry the polled gene.

We recently installed a 27.6 kW solar system consisting of four 30 panel arrays on two axis solar trackers. The grid tied system is sized to meet the annual electrical needs of our main farmstead.

We received a raw milk permit from NYS Department of Ag & Markets early in 2009 and began offering farm fresh milk to customers at the farm.

We are currently in the midst of an addition/restoration project surrounding our milkhouse. One side of the addition provides a safer, more attractive entrance for our fresh milk customers as well as offers us needed storage room for barn supplies and equipment. The addition on the other side of the milkhouse will house a bathroom, a washing machine so we can switch from paper towels to cloth towels for cow prep, and an office/breakroom. In doing the project, we also took off the existing milkhouse roof and replaced it with a new roof over the milkhouse and additions, found rotting beams that have been replaced, and replaced an existing problematic stairway to the haymow with a much safer design.

4. Participants

Linda Tikofsky, Senior Extension Veterinarian at Cornell University's Quality Milk Production Services (QMPS), took the lead role in this study by organizing and orchestrating the collection and storage of all milk samples and farm data and sending the samples to the Michigan State University Laboratory for testing. QMPS staff collected the samples and data at the farms. Dr Tikofsky analyzed the resulting data and submitted a written report to OFRF (report is attached).

Eight certified organic (O), five conventional grazing (G) and four conventional non-grazing (NG) herds located in Central New York state participated in the study. 20 farms had been initially been planned, but varying circumstances dropped the final number of participating farms to 17. Bulk milk samples, production data, diet information (including pound of dry matter from pasture) and number of animals milking on these farms was collected monthly from November 2005 to October 2006. One organic herd and one grazing herd dried all cows off from January until March; data for these herds is limited to eight months.

5. Project activities

All farms were visited monthly by QMPS staff on two consecutive days each month from November 2005 to October 2006. At each farm visit, a bulk milk sample was collected into a 236 ml sterile container after five minutes of agitation and was placed on ice in a cooler for transport back to the laboratory. At the laboratory, a 30 ml aliquot of milk was removed from each sample and submitted for somatic cell counting. All remaining milk samples were stored at -80 ^{0}C until submitted for analysis. Milk production, herd numbers, and diet information was collected at each farm visit.

I helped develop the feed data worksheet and assisted in identifying organic dairy farm participants for the study. Dr. Tikofsky lined up all the farms, set up the sample collection procedures, and interfaced with the lab at the Nutrition Section of the Diagnostic Center for Population and Animal Health at Michigan State University (Lansing, MI) which tested all 198 samples for 36 essential fatty acids, Vitamin A, and Vitamin E.

6. Results
Part A

Dr. Linda Tikofsky wrote the following study results in her report to OFRF. Rather than paraphrase, I am copying her complete text and tables to include the full data in this SARE report, but all the credit for this Part A section goes to Dr. Tikofsky.

Descriptive statistics for farms

Summary statistics for farms participating in the study are included in Table 1 and include herd size, average annual production per cow and average percent of dry matter intake (DMI) from pasture during the grazing season. For Central New York in 2006, the grazing season extended from May until October. Fourteen farms were predominantly Holstein-Friesian; two farms (one organic and one grazing conventional) were mixed breeds.

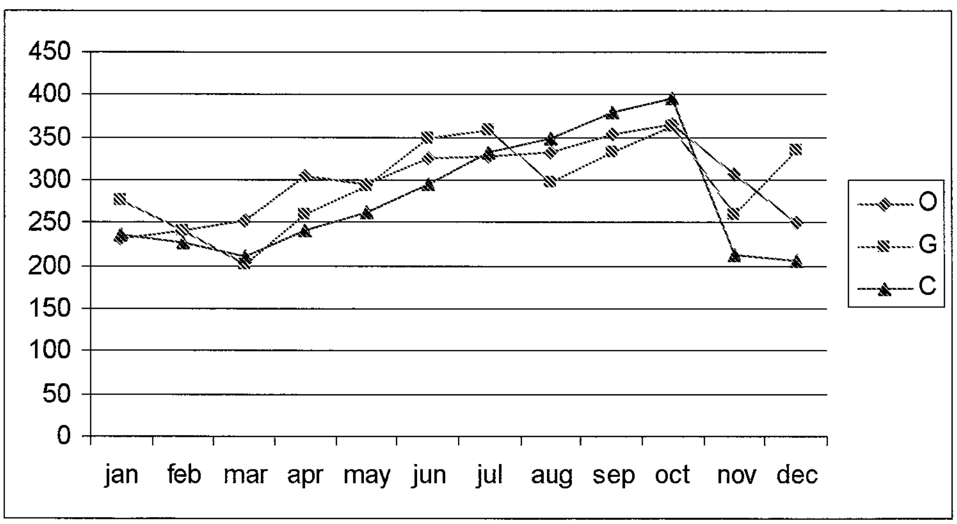
Table 1: Descriptive statistics for participating herds

	Organic n=8				***Grazing Conventional n=5***				***Non-grazing Conventional n=4***				
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	
Herd size	99	95	40	325	62	11	50	80	167	107	98	325	n.s.
Average Annual Production/ cow (lbs)	16295	3794	9760	20435	16927	1100	15250	18300	20496	2035	18240	23180	p=0.08
% dmi from pasture (May-October, inclusive)	52	19	32	97	18	8	10	26	0	0	0	0	p=0.002

Vitamin A

Vitamin A levels did not differ significantly among farm type (Figure 1). Levels for all farms increased from April through October. There was a trend (though not significant) for organic and grazing herds to have higher vitamin A levels than conventional non-grazing April through July, but this tendency was reversed August through October.

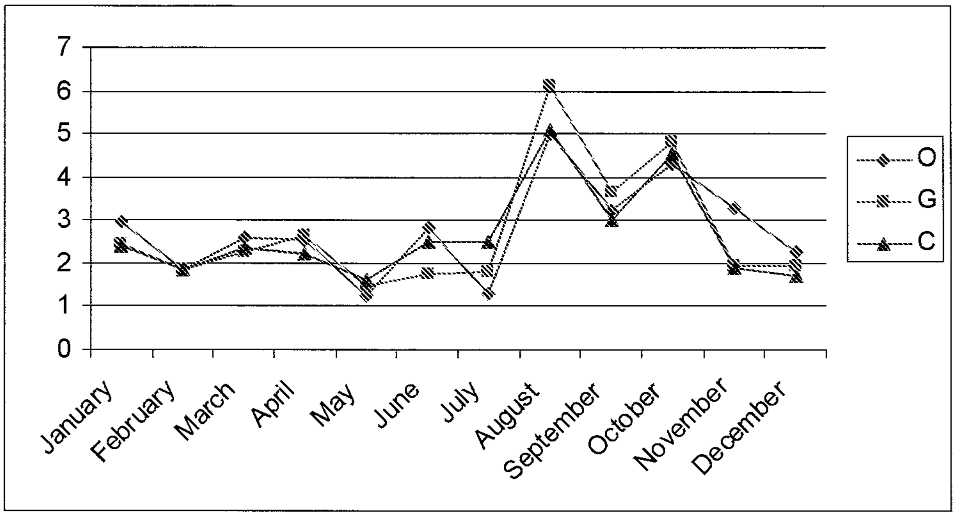
Figure 1: Vitamin A levels by management system



Vitamin E

Vitamin E levels ranged between 1 and 3 μg/ml from January through July and then increased sharply for August and then began decreasing (Figure 2). Overall there were no significant differences among farm types. However, GC herds has significantly higher levels of vitamin E in August than either NC or O herds (p=0.02); O herds had significantly higher vitamin E content than GC or NC herds in November (p=0.001).

Figure 2. Vitamin E level by farm type



Fatty acid content

The mean percentage, standard deviation, maximum and minimum levels of each of the fatty acid groups and individual fatty acids in organic, conventional grazing and conventional non-grazing milk averaged over the twelve months of the study are presented in Appendix A. Conventional grazing, conventional non-grazing and organic did not differ across the year with respect to any fatty acid group or individual fatty acid.

Table 2. Mean percentage of each fatty acid averaged over 12 month study period. Values expressed as percentage of total fatty acids.

	Mean			Standard Deviation			Lowest Value Observed			Highest Value Observed		
Fatty Acid	NGC	GC	O	NGC	GC	O	NGC	GC	O	NGC	GC	O
4:0	3.769	3.709	3.762	0.499	0.526	0.584	2.745	2.665	0.584	4.688	4.935	5.254
6:0	2.422	2.387	2.422	0.375	0.365	0.370	1.773	1.725	1.752	3.092	3.129	3.133
8:0	1.455	1.469	1.492	0.205	0.241	0.215	1.041	0.994	0.991	1.806	1.944	1.969
10:0	3.224	3.510	3.293	0.497	0.527	0.535	2.391	2.414	2.330	4.416	4.824	4.354
12:0	3.909	3.748	3.915	0.626	0.552	0.689	2.730	2.761	2.734	5.134	4.926	5.439
13:0	0.043	0.044	0.043	0.007	0.007	0.007	0.032	0.033	0.029	0.056	0.059	0.060

14:0	11.309	11.241	11.451	1.631	1.703	1.651	8.539	7.995	8.270	14.052	15.036	15.173
15:0	1.320	1.327	1.312	0.229	0.211	0.203	0.943	0.960	0.947	1.905	1.794	1.714
16:0	31.470	30.820	30.830	3.187	3.157	3.620	25.877	23.785	24.012	36.681	35.822	36.866
17:0	0.664	0.643	0.653	0.101	0.107	0.107	0.476	0.457	0.428	0.855	0.840	0.857
18:0	9.284	9.847	9.742	1.256	1.439	1.425	6.736	6.953	7.006	12.029	12.742	12.716
20:0	0.137	0.139	0.143	0.019	0.020	0.024	0.102	0.100	0.094	0.182	0.184	0.195
22:0	0.043	0.041	0.041	0.006	0.007	0.007	0.029	0.030	0.029	0.056	0.061	0.057
Total Saturated Fatty Acids	*69.049*	*68.925*	*69.100*	*2.313*	*2.477*	*2.546*						
12:1	0.049	0.049	0.049	0.007	0.008	0.007	0.036	0.033	0.034	0.069	0.068	0.066
14:1	0.988	0.953	0.959	0.146	0.163	0.157	0.700	0.685	0.688	1.244	1.312	1.327
15:1	0.031	0.031	0.031	0.005	0.004	0.005	0.022	0.023	0.022	0.040	0.041	0.041
16:1	1.497	1.491	1.507	0.241	0.252	0.256	1.043	1.049	1.048	1.922	1.970	2.053
17:1	0.373	0.357	0.366	0.057	0.056	0.061	0.262	0.262	0.243	0.512	0.475	0.511
18:1	17.381	17.558	17.339	3.468	3.727	4.683	12.694	12.842	13.241	21.440	21.052	21.313
20:1	0.167	0.160	0.166	0.022	0.022	0.022	0.127	0.123	0.128	0.213	0.216	0.226
22:1	0.002	0.002	0.002	0.000	0.000	0.000	0.002	0.002	0.002	0.003	0.003	0.003
Total Mono-unsaturated fats, cis	*20.062*	*20.181*	*19.999*	*2.287*	*2.351*	*2.322*						
18:2	2.827	2.834	2.867	0.393	0.468	0.433	2.242	2.007	2.091	3.692	3.850	3.965
18:3	0.449	0.450	0.455	0.070	0.067	0.072	0.344	0.344	0.328	0.598	0.601	0.601
20:2	0.220	0.210	0.209	0.034	0.027	0.037	0.156	0.148	0.148	0.297	0.275	0.282
20:3	0.055	0.053	0.053	0.007	0.006	0.007	0.040	0.040	0.040	0.074	0.064	0.072
20:4	0.128	0.122	0.125	0.020	0.017	0.021	0.092	0.088	0.091	0.165	0.161	0.177
20:5	0.021	0.021	0.021	0.003	0.003	0.003	0.015	0.015	0.015	0.026	0.028	0.029
22:2	0.017	0.016	0.017	0.002	0.003	0.003	0.013	0.012	0.012	0.021	0.022	0.024
22:3	0.001	0.001	0.002	0.000	0.000	0.000	0.001	0.001	0.001	0.002	0.002	0.002
22:4	0.003	0.003	0.003	0.001	0.001	0.001	0.003	0.002	0.002	0.005	0.005	0.005
22:5	0.064	0.062	0.062	0.009	0.010	0.010	0.046	0.043	0.043	0.080	0.088	0.085
22:6	0.002	0.002	0.002	0.000	0.000	0.000	0.002	0.002	0.002	0.003	0.003	0.003
Total Poly-unsaturated fats, cis	*3.768*	*3.754*	*3.796*	*0.413*	*0.490*	*0.463*						
14:1t	0.028	0.027	0.028	0.004	0.004	0.005	0.020	0.021	0.019	0.036	0.035	0.037
16:1t	0.013	0.012	0.013	0.002	0.002	0.002	0.010	0.009	0.009	0.016	0.016	0.018
18:1t	0.529	0.521	0.533	0.088	0.076	0.080	0.388	0.390	0.360	0.741	0.733	0.690
18:2t	0.092	0.088	0.090	0.017	0.014	0.015	0.067	0.065	0.062	0.130	0.118	0.122
Total trans fatty acids	*0.662*	*0.650*	*0.664*	*0.092*	*0.080*	*0.085*						
Total CLA	*0.709*	*0.663*	*0.693*	*0.110*	*0.110*	*0.116*						

Saturated fatty acids (SFA)

Only one SFA showed differences across the year, C 18:0. Levels for CG were higher in the spring and levels for O were higher in the fall. For the remaining SFA, overall there were no significant differences among the three groups across the year, although for occasional months there were significant differences. Milk from organic herds tended to be higher in butyric acid (C4:0) in March (p=0.08), in palmitic acid (C16:0) in October (p=0.03) and in arachidic acid (C20:0) in July (p=0.02). For CNG herds, myristic acid levels (C14:0), level in milk were lower in July (p=0.02).

Mono-unsaturated fatty acids (MFA), cis

There were no significant differences among the three groups across the year, nor were there any significant monthly differences.

Poly-unsaturated fatty acids (PFA), cis

There were no significant differences among the three groups across the year, but there were some significant monthly differences. O and CNG herds had higher levels of linoleic acid (C18:2) than CG herds in June (p=0.043) and O herds had significantly higher levels of this same fatty acid in October (p=0.017). There was also a tendency (though not significant) for levels of γ-linoleic acid to be higher in milk from O herds in June (p=0.094). CNG had higher levels of arachadonic acid (C20:4) than O herds in February (p=0.004), September (p=0.068) and November (p=0.08) while CG herd exhibited significantly lower levels of this fatty acid in December (p=0.002). Levels of C22:2 were higher for O herds in June (p=0.006) while level of C22:3 were lower for CNG herds than the other two groups in May (p=0.006).

Trans Fatty Acids (TFA)

Overall there were no significant differences among the three herd categories for any *trans* fatty acid. Levels of C16:1t were higher for O herds in October (p=0.047) and levels of trans vaccenic acid were highest for O herds in June (p=0.05) and July (p=0.08).

Conjugated Linoleic Acid (CLA)

No significant differences were detected among the groups overall for either of the CLA's, but there were some significant monthly differences. Levels of *cis*-9, *trans*-11 CLA tended to be higher for O herds in May (p=0.07) and for CNG herds in August (p=0.06). For *trans*-10, *cis*-12 CLA, O herds had significantly higher levels in milk (p=0.017).

Part B

Our farm was one of the participating certified organic herds in this study with 11 samples (Dec. '05 through Oct. '06). In looking at our individual farm test results for Vitamin E and the 2 CLA's (*cis*-9, *trans*-11 CLA and *trans*-10, *cis*-12 CLA), there is no discernable trend over the months; the numbers varied all over the place. For example, the rank of values for Vitamin E by consecutive month, starting with December '05, are as follows: 8, 2, 7, 5, 4, 10, 1, 9, 11, 6, 3. The Vitamin E values ranged from a low of .92 ug/mL in August to a high of 5.71 in June, the June level being 6.2 times higher than the August level. There was not quite such a dramatic variation during the non-grazing season, although there still was quite a range: from 1.78 ug/ml in December to 4.84 in January—an increase of 2.7 times. There did not appear to be a correlation with amount of pasture intake.

Vitamin A, however, did show a significant difference as the five highest values were during the grazing season—May through October. The average value for Vitamin A from May through October was 405 ng/mL versus an average of 268 for December through April—a 51% increase during the grazing season, although a spike in August brought the average up considerably. However, as noted by Dr. Tikofsky in her report, all the farm management types saw an increase in Vitamin A from April through October and not just the grazing farms.

A few other observations on our data: in August when we had the highest Vitamin A value, we had our lowest Vitamin E reading; May did show some of the highest levels of CLA. Looking at the averages of CLA values for months with grazing and months without, the average of C18:2t10c12 levels for the 5 main months of grazing was .0214 versus .0204 for the 5 months with no grazing. For C18:2c9t11 the averages were reversed with the non grazing months average being a tad higher at .684 versus .671 for the 5 main grazing months. I don't know statistics well enough to verify if these difference are statisically significant, but I would expect that they are not.

Overall, I could reach no conclusions as to what factors may be influencing differences in these nutrient levels.

7. Conditions

The 2006 grazing season saw higher than normal rainfall during the summer months (June-7.48", July-7.31', August5.22") so summer pasture growth was greater than normal.

8. Economics

Because the results of this study did not show significantly different nutrient values between the three farm management types, this study cannot be used to promote one type of management over another as definitively leading to higher levels of essential fatty acids or Vitamins A and E in milk.

9. Assessment

The study results, showing little to no significant differences in the nutrient levels trending over time in the three management systems, was unexpected, given much research in recent years showing increased levels of favorable essential fatty acids when cows have higher levels of pasture in their diet. Other studies have also shown higher vitamin values for organic milk. This study did not corroborate similar findings, although Dr. Tikofsky did note that "milk from cows with a high percentage of dry matter intake coming from lush pasture did tend to have higher levels of some nutrients beneficial to human health."

10. Adoption

Since there are no definitive results relative to one management system leading to more nutrients in milk, no recommendation can flow from this study as to adoption of a certain management style to elevate Vitamins A, E or essential fatty acids.

11. Outreach

I attended the March 3-6, 2009 Northeast Pasture Consortium Meeting in Morgantown, WV, and presented a poster report of this study. Dr. Tikofsky designed the laminated poster showing the data charts. Dr. Tikofsky submitted her written report to OFRF and the study results will be available on the Quality Milk Production Services website (www.qmps.vet.cornell.edu). Participating farmers will receive their own farm's results along with the findings from the study.

Because of minimal results, greater outreach efforts are not merited.

12. Report Summary

The purpose of this SARE grant was to synergize research efforts. It expanded an already funded OFRF study led by Dr. Linda Tikofsky of Quality Milk Production Services at Cornell University to include testing for Vitamins A and E, along with a full range of fatty acid levels, in the milk of farms under three different management systems: organic, conventional grazing, and conventional confinement.

Bulk milk samples and farm data were collected from 17 farms in Central New York from November 2005 through October 2006. The samples were sent to the Diagnostic Center for Population and Animal Health at Michigan State University for nutrient testing.

Dr. Tikofsky analyzed the data and concluded that "A multitude of factors influence the fatty acid and vitamin content of bovine milk, including farm management, season, geography, diet and breed. Many of these aspects are not easily quantifiable. This study did not elucidate statistically significant differences in milk from three management styles. However, milk from cows with a high percentage of dry matter intake coming from lush pasture did tend to have higher levels of some nutrients beneficial to human health. A larger study, limited to the grazing season and including more frequent sampling would be necessary to confirm the trends seen here."

Kathie Arnold
1/15/2010

Report Appendices that are a separate file:
-spreadsheet of Twin Oaks Dairy LLC showing nutrient values and their rank by month, and BF, protein, MUN, SCC, and % dry matter intake (DMI) from pasture for each month
-spreadsheet of all farm's individual nutrient values / charts with only our farm identified; the others identified as O (organic), G (conventional grazing), or C (conventional confinement)

Appendix 1

Longitudinal comparison of fatty acid composition and conjugated linoleic acid levels among three different management systems.

Principle Investigator: Linda L. Tikofsky. DVM. Quality Milk Production Services. Cornell University. 22 Thornwood Drive, Ithaca NY 14850. Phone: 607.255.8202. LG40@cornell.edu

Introduction

Milk is generous source of valuable nutrients (energy, protein, fatty acids and essential minerals and vitamins) and consumers are becoming more aware of the link between diet and health. Omega-fatty acids and conjugated linoleic acid (CLA) have been shown to have beneficial impacts on human health (Ip et al., 1991; Hu and Willet, 2002). Many seek out organic meat and milk products and expect that these products will have greater health benefits than conventionally produced products. Since access to pasture is a requirement of organic production, one would expect organic dairy products to have enhanced levels of the 'functional food', conjugated linoleic acid.

Only a limited number of studies have looked at the impact of feeding systems on milk CLA levels under field conditions and none of these have been performed in US management systems. Two studies from Germany evaluate differences in diets consumed in the field. The first study by Jahreis, et al. (1997) compared bulk milk samples over time for three different management systems and determined that milk CLA levels were higher in pastured animals and varied over the year. This study has its limitations because each treatment group was represented by only one farm. The second German (Kraft et al. 2003) study compared indoor cows in central Germany with pastured Alpine cows and determined an increase in CLA levels for the pastured group. No comparison with a TMR herd was made and herds were located in geographically diverse areas of Germany.

Ellis et al. (2006) performed a 12 month longitudinal study in the UK evaluating fatty acids levels, Vitamin E and Vitamin A in bulk milk from 17 organic and 19 conventional herds. There was no difference found in CLA levels or vaccenic acid between the two groups although organic milk did have a higher proportion of omega-3 fatty acids when compared with conventional milk throughout the year. Although there were no differences between the two types in Vitamin E levels in milk; conventionally produced milk did have a higher Vitamin A level (Ellis et al., 2007).

No studies to date have looked at the variability of milk composition and CLA levels among organic, conventional grazing and conventional non-grazing herds over time and changing seasonal conditions in the United States. To date, limited information is available describing milk composition, milk quality parameters, or CLA for organic herds in the US system.

Objectives

The objective of this study was to determine if there was a difference in Vitamin A, Vitamin E. conjugated linoleic acid and other fatty acids among milk from certified organic, conventional grazing, and conventional non-grazing herds in a region of New York state. In our initial plan, fatty acid analysis was to be performed at the laboratory of Dr. Dale Bauman; however, costs to run all samples in that laboratory were prohibitive so fatty acid and vitamin analyses were performed at the Animal Health Diagnostic Center at Michigan State University.

Materials and Methods

Milk sample collection

Eight certified organic (O), five conventional grazing (G) and four conventional non-grazing (NG) herds located in Central New York state were invited to participate in the study. All farms were visited monthly on two consecutive days each month from November 2005 to October 2006. At each farm visit, a bulk milk sample was collected into a 236 ml sterile container after five minutes of agitation and was placed on ice in a cooler for transport back to the laboratory. At the laboratory, a 30 ml aliquot of milk was removed from each sample and submitted for somatic cell counting. All remaining milk samples were stored at -80 ^{0}C until submitted for analysis. Milk production and diet information was collected at each farm visit. One organic herd and one grazing herd dried all cows off from January until March; data for these herds is limited to eight months.

Production data, diet information (including pound of dry matter from pasture) and number of animals milking were collected from each farm at each visit.

Sample analysis

A total of 198 samples were shipped on ice by overnight express to the Nutrition Section of the Diagnostic Center for Population and Animal Health at Michigan State University (Lansing, MI).________ All analysis was performed on a Perkin Elmer Clarus 500 Gas Chromatograph. Hydrogen was the carrier gas at a flow of 0.50ml/m. Prepared samples were injected into a split/splitless inject at a split ration of 4:1 and a temperature of 255°C. A Supelco SP2560 Fused Silica Capillary column at 100m x 0.25mm with a 0.2um film thickness was used to resolve the fatty acid methyl esters in each sample. The oven program used is as follows: Hold at 70°C for 4 min ramp to 175°C at 13°C/min hold 27 min, ramp to 215°C at 4°C/min to 215 and hold for 20min. Run time was a total of 69 min. The resolved components were detected by a flame ionization detector with a air flow of 400mL and a hydrogen flow of 45mL. The temperature of the detector was set at 255°C. Results for fatty acids were reported as a percentage of total fat; Vitamins A and E were reported as µg/ml.

Somatic cell counting was performed by the Fossomatic™ (FOSS, Denmark) method at Dairy One Laboratories (Ithaca, NY).

Statistical analyses
Fatty acid and vitamin A and E content of the milk samples were analyzed using Microsoft Excel and Statistix (version 8.0, Analytical Software, Tallahassee FL). Summary statistics by farm system type and mean, median, standard deviation, minimum and maximum were calculated for each individual fatty acid (FA) and vitamin A and E. A one-way analysis of variance (ANOVA) was used to test for differences among farm system type. Results are reported for each variable by month and for the year.

Results

Descriptive statistics for farms
Summary statistics for farms participating in the study are included in Table 1 and include herd size, average annual production per cow and average percent of dry matter intake (DMI) from pasture during the grazing season. For Central New York in 2006, the grazing season extended from May until October. Fourteen farms were predominantly Holstein-Friesian; two farms (one organic and one grazing conventional) were mixed breeds.

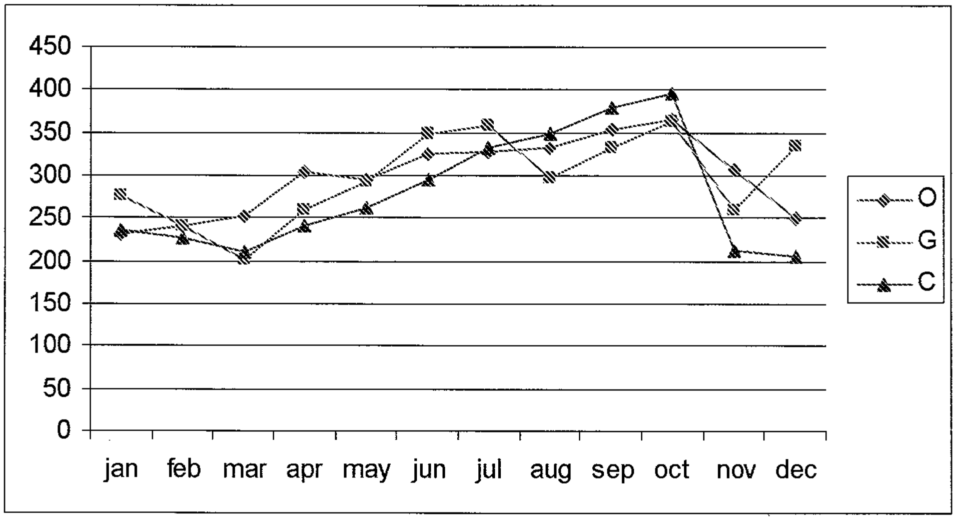
Table 1: Descriptive statistics for participating herds

	Organic n=8				Grazing Conventional n=5				Non-grazing Conventional n=4				
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	
Herd size	99	95	40	325	62	11	50	80	167	107	98	325	n.s.
Average Annual Production/ cow (lbs)	16295	3794	9760	20435	16927	1100	15250	18300	20496	2035	18240	23180	p=0.08
% dmi from pasture (May-October, inclusive)	52	19	32	97	18	8	10	26	0	0	0	0	p=0.002

Vitamin A

Vitamin A levels did not differ significantly among farm type (Figure 1). Levels for all farms increased from April through October. There was a trend (though not significant) for organic and grazing herds to have higher vitamin A levels than conventional non-grazing April through July, but this tendency was reversed August through October.

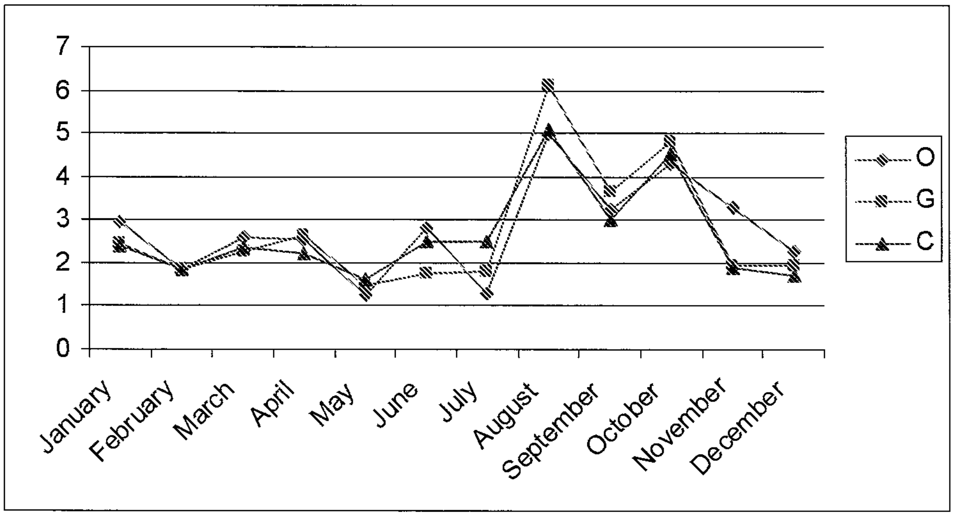
Figure 1: Vitamin A levels by management system



Vitamin E

Vitamin E levels ranged between 1 and 3 μg/ml from January through July and then increased sharply for August and then began decreasing (Figure 2). Overall there were no significant differences among farm types. However, GC herds has significantly higher levels of vitamin E in August than either NC or O herds ($p=0.02$); O herds had significantly higher vitamin E content than GC or NC herds in November ($p=0.001$).

Figure 2. Vitamin E level by farm type



Fatty acid content

The mean percentage, standard deviation, maximum and minimum levels of each of the fatty acid groups and individual fatty acids in organic, conventional grazing and conventional non-grazing milk averaged over the twelve months of the study are presented in Appendix A. Conventional grazing, conventional non-grazing and organic did not differ across the year with respect to any fatty acid group or individual fatty acid.

Table 2. Mean percentage of each fatty acid averaged over 12 month study period. Values expressed as percentage of total fatty acids.

	Mean			Standard Deviation			Lowest Value Observed			Highest Value Observed		
Fatty Acid	NGC	GC	O	NGC	GC	O	NGC	GC	O	NGC	GC	O
4:0	3.769	3.709	3.762	0.499	0.526	0.584	2.745	2.665	0.584	4.688	4.935	5.254
6:0	2.422	2.387	2.422	0.375	0.365	0.370	1.773	1.725	1.752	3.092	3.129	3.133
8:0	1.455	1.469	1.492	0.205	0.241	0.215	1.041	0.994	0.991	1.806	1.944	1.969
10:0	3.224	3.510	3.293	0.497	0.527	0.535	2.391	2.414	2.330	4.416	4.824	4.354
12:0	3.909	3.748	3.915	0.626	0.552	0.689	2.730	2.761	2.734	5.134	4.926	5.439
13:0	0.043	0.044	0.043	0.007	0.007	0.007	0.032	0.033	0.029	0.056	0.059	0.060
14:0	11.309	11.241	11.451	1.631	1.703	1.651	8.539	7.995	8.270	14.052	15.036	15.173
15:0	1.320	1.327	1.312	0.229	0.211	0.203	0.943	0.960	0.947	1.905	1.794	1.714
16:0	31.470	30.820	30.830	3.187	3.157	3.620	25.877	23.785	24.012	36.681	35.822	36.866
17:0	0.664	0.643	0.653	0.101	0.107	0.107	0.476	0.457	0.428	0.855	0.840	0.857
18:0	9.284	9.847	9.742	1.256	1.439	1.425	6.736	6.953	7.006	12.029	12.742	12.716
20:0	0.137	0.139	0.143	0.019	0.020	0.024	0.102	0.100	0.094	0.182	0.184	0.195
22:0	0.043	0.041	0.041	0.006	0.007	0.007	0.029	0.030	0.029	0.056	0.061	0.057
Total Saturated Fatty Acids	*69.049*	*68.925*	*69.100*	*2.313*	*2.477*	*2.546*						
12:1	0.049	0.049	0.049	0.007	0.008	0.007	0.036	0.033	0.034	0.069	0.068	0.066
14:1	0.988	0.953	0.959	0.146	0.163	0.157	0.700	0.685	0.688	1.244	1.312	1.327
15:1	0.031	0.031	0.031	0.005	0.004	0.005	0.022	0.023	0.022	0.040	0.041	0.041
16:1	1.497	1.491	1.507	0.241	0.252	0.256	1.043	1.049	1.048	1.922	1.970	2.053
17:1	0.373	0.357	0.366	0.057	0.056	0.061	0.262	0.262	0.243	0.512	0.475	0.511
18:1	17.381	17.558	17.339	3.468	3.727	4.683	12.694	12.842	13.241	21.440	21.052	21.313

20:1	0.167	0.160	0.166	0.022	0.022	0.022	0.127	0.123	0.128	0.213	0.216	0.226
22:1	0.002	0.002	0.002	0.000	0.000	0.000	0.002	0.002	0.002	0.003	0.003	0.003
Total Mono-unsaturated fats, cis	*20.062*	*20.181*	*19.999*	*2.287*	*2.351*	*2.322*						
18:2	2.827	2.834	2.867	0.393	0.468	0.433	2.242	2.007	2.091	3.692	3.850	3.965
18:3	0.449	0.450	0.455	0.070	0.067	0.072	0.344	0.344	0.328	0.598	0.601	0.601
20:2	0.220	0.210	0.209	0.034	0.027	0.037	0.156	0.148	0.148	0.297	0.275	0.282
20:3	0.055	0.053	0.053	0.007	0.006	0.007	0.040	0.040	0.040	0.074	0.064	0.072
20:4	0.128	0.122	0.125	0.020	0.017	0.021	0.092	0.088	0.091	0.165	0.161	0.177
20:5	0.021	0.021	0.021	0.003	0.003	0.003	0.015	0.015	0.015	0.026	0.028	0.029
22:2	0.017	0.016	0.017	0.002	0.003	0.003	0.013	0.012	0.012	0.021	0.022	0.024
22:3	0.001	0.001	0.002	0.000	0.000	0.000	0.001	0.001	0.001	0.002	0.002	0.002
22:4	0.003	0.003	0.003	0.001	0.001	0.001	0.003	0.002	0.002	0.005	0.005	0.005
22:5	0.064	0.062	0.062	0.009	0.010	0.010	0.046	0.043	0.043	0.080	0.088	0.085
22:6	0.002	0.002	0.002	0.000	0.000	0.000	0.002	0.002	0.002	0.003	0.003	0.003
Total Poly-unsaturated fats, cis	*3.768*	*3.754*	*3.796*	*0.413*	*0.490*	*0.463*						
14:1t	0.028	0.027	0.028	0.004	0.004	0.005	0.020	0.021	0.019	0.036	0.035	0.037
16:1t	0.013	0.012	0.013	0.002	0.002	0.002	0.010	0.009	0.009	0.016	0.016	0.018
18:1t	0.529	0.521	0.533	0.088	0.076	0.080	0.388	0.390	0.360	0.741	0.733	0.690
18:2t	0.092	0.088	0.090	0.017	0.014	0.015	0.067	0.065	0.062	0.130	0.118	0.122
Total trans fatty acids	*0.662*	*0.650*	*0.664*	*0.092*	*0.080*	*0.085*						
Total CLA	*0.709*	*0.663*	*0.693*	*0.110*	*0.110*	*0.116*						

Saturated fatty acids (SFA)

Only one SFA showed differences across the year, C 18:0. Levels for CG were higher in the spring and levels for O were higher in the fall. For the remaining SFA, overall there were no significant differences among the three groups across the year, although for occasional months there were significant differences. Milk from organic herds tended to be higher in butyric acid (C4:0) in March (p=0.08), in palmitic acid (C16:0) in October (p=0.03) and in arachidic acid (C20:0) in July (p=0.02). For CNG herds, myristic acid levels (C14:0), level in milk were lower in July (p=0.02).

Mono-unsaturated fatty acids (MFA), cis

There were no significant differences among the three groups across the year, nor were there any significant monthly differences.

Poly-unsaturated fatty acids (PFA), cis

There were no significant differences among the three groups across the year, but there were some significant monthly differences. O and CNG herds had higher levels of linoleic acid (C18:2) than CG herds in June (p=0.043) and O herds had significantly higher levels of this same fatty acid in October (p=0.017). There was also a tendency (though not significant) for levels of γ-linoleic acid to be higher in milk from O herds in June (p=0.094). CNG had higher levels of arachadonic acid (C20:4) than O herds in February (p=0.004), September (p=0.068) and November (p=0.08) while CG herd exhibited significantly lower levels of this fatty acid in December (p=0.002). Levels of C22:2 were higher for O herds in June (p=0.006) while level of C22:3 were lower for CNG herds than the other two groups in May (p=0.006).

Trans Fatty Acids (TFA)

Overall there were no significant differences among the three herd categories for any *trans* fatty acid. Levels of C16:1t were higher for O herds in October (p=0.047) and levels of trans vaccenic acid were highest for O herds in June (p=0.05) and July (p=0.08).

Conjugated Linoleic Acid (CLA)

No significant differences were detected among the groups overall for either of the CLA's, but there were some significant monthly differences. Levels of *cis*-9, *trans*-11 CLA tended to be higher for O herds in May (p=0.07) and for CNG herds in August (p=0.06). For *trans*-10, *cis*-12 CLA, O herds had significantly higher levels in milk (p=0.017).

Discussion

Because of the high level of dry matter intake provided by pasture in organic cow diets, we expected to see significant elevations of beneficial fatty acids, Vitamin A and Vitamin E in organic milk during the grazing season and decreasing levels as percentage dry matter intake from pasture decreased in diets. However, this was not our finding.

All herds experienced an increase in vitamin A and vitamin E levels in milk during the spring and summer months which decreased during the winter housing season. During the grazing season, O and CG herds had access to pasture which can explain their increased levels in milk, CNG do not. However, it is common for CNG farms to begin feeding current season hay and/or 'green chop' to cows as soon as the first cutting is taken. This fresh hay may explain the similar increase in these vitamin levels in milk from CNG. CNG herds also received and average of 22 lbs of commercial grain and concentrate mix per head per day which was supplemented in all cases with a vitamin and mineral mix. One organic herd fed no grain at all while the rest fed an average of 10 (range 2.5 to 17) pounds of grain per head per day during the grazing season. This grain was provided largely by components rather than as a commercially prepared mix. Most organic farms fed minerals and vitamins free choice, rather than as part of a total mixed ration. This mirrors the findings of Ellis et al. (2007) who found that feeding higher levels of concentrate was associated with increased milk vitamin A, vitamin E and β-carotene.

Fatty acid content of milk from the three groups in our study mirrored previous reports of bovine milk fatty acids (Mansson, 2008). Although not significant in most cases, there was a tendency for organic milk to be higher in poly-unsaturated fatty acids (PUFA) and in two of the omega-3 fatty acids [α-linolenic and eicosapentoic (e.p.a)] during the grazing season. Ellis et al. (2006) found significantly increased levels of these important compounds in organic milk when compared with conventional. Small sample size likely had an impact of the results of our study since we were constrained by finances and the number of farms that could be visited in a 48-hour period monthly. Our study included only 17 farms in total whereas Ellis et al. (2006) studied 36 farms in the UK. Including additional farms may have increased the power of our study and made trends statistically significant. Since PUFA and omega-3 fatty acids have been positively associated with human health, milk from animals feeding on rapidly growing pastures (as is the case in the study's geographical region) potentially could be an important source of these nutrients.

There were no differences in the percentage content of the two CLA isomers among the three groups; again similarly to Ellis' findings (2006) and those of Toledo et al. (2003) who conducted a 12 month study comparing bulk milk samples from organic and conventional farms in Sweden. There was a significant increase in the percentage of *cis*-9, *trans*-11 CLA in organic milk in May but this was not sustained through the grazing season. Although CNG herds did not have access to fresh pasture, all of these herds received approximately 3 pounds of DMI per head per day of soybeans, which have been demonstrated to have a positive effect on the CLA content of milk from supplemented cows (Solomon et al., 2000)(Abu-Gazaleh, et al., 2002). Corn distillers solubles is also a common ingredient in Northeast US diets and was included in one of the CNG rations. Corn distillers solubles has been shown to increase CLA levels in bovine milk (Bharathan et al., 2008).

We did note increased *trans*-vaccenic acid (TVA;C18:1, *trans*-11) in milk from organic herds in June and July. TVA is a precursor to *cis*-9, *trans*-11 CLA and has been shown to be protective against mammary cancer in rats (Lock et al., 2004). TVA is converted to CLA in mammary tissue but it has been demonstrated *in vitro* that some human tissues, including intestines, can convert TVA to CLA (Renaville et al., 2006), potentially increasing the health benefit of organic milk.

Although we attempted to quantify nutrients included in all groups' diets, there is need for additional detail. Conventional rations designed by nutritionists working for commercial feed companies are usually proprietary, so it was difficult to ferret out all ingredients included in the CNG groups. These diets may have included fat from oils known to have a positive effect on CLA content (e.g., sunflower oil, soybean oil). It would also be interesting to know the composition of grazing pastures as this has been shown to impact fatty acid composition of bovine milk (Hauswirth et al., 2004).

Conclusions

A multitude of factors influence the fatty acid and vitamin content of bovine milk, including farm management, season, geography, diet and breed. Many of these aspects are not easily quantifiable. This study did not elucidate statistically significant differences in milk from three management styles. However, milk from cows with a high percentage of dry matter intake coming from lush pasture did tend to have higher levels of some nutrients beneficial to human health. A larger study, limited to the grazing season and including more frequent sampling would be necessary to confirm the trends seen here.

Outreach

Results of this study were presented at the Northeast Pasture Consortium annual meeting (May, 2009) and results will be available on the Quality Milk Production Services website (www.qmps.vet.cornell.edu). Participating farmers will receive their own farm's results along with the findings from the study.

References

Abu-Gazaleh AA, DJ Schingoethe, AR Hippen and LA Whitlock. 2002. *Feeding of fish meal and extruded soybeans enhances the conjugated linoleic acid (CLA) content of milk.* J Dairy Sci. 85:624-631.

Bharathan M, DJ Schingoethe, AR Hippen, KF Kalscheur, ML Gibson and K Karges. 2008. *Conjugated linoleic acid increases in milk from cows fed condensed distillers solubles and fish oil.* J Dairy Sci. 91:2796-2807.

Ellis KA, G Innocent, D Grove-White, P Cripps, WG McLean, CV Howard and M Mihm. 2006. *Comparing the fatty acid composition of organic and conventional milk.* J Dairy Sci. 89:1938-1950.

Ellis KA, A Montiero, GT Innocent, D Grove-White, P Cripps, WG McLean, CV Howard and M Mihm. 2007. *Investigation of the vitamins A and E and β-carotene content in milk from UK organic and conventional dairy farms.* J Dairy Res. 74:484-491.

Hauswirth CB, MRL Scheeder and JH Beer. 2004. *High n-3 fatty acid content in Alpine cheese-the basis for an Alpine paradox.* Circulation 109:103-107.

Hu FB and WC Willett. 2002. *Optimal diets for prevention of coronary heart disease.* JAMA. 288:2569-2578.

Ip C, SF Chin, A Scimeca and MW Pariza. 1991. *Mammary cancer prevention by conjugated dienoic derivative of linoleic acid.* Cancer Res. 51:6118-6124.

Jahreis G, J Fritsche, H. Steinhart. 1996. *Monthly varioations of milk compostion with special regard to fatty acides depending on season and farm management systems—conventional versus ecological.* Fett. Lipid. 98:356-359.

Lock AL, PC Garnsworthy. 2003. *Seasonal variation in milk conjugated linoleic acid and Δ9-desaturase in dairy cows.* Livest Prod Sci. 79:47-59.

Månsson, HL. 2008. *Fatty acids in bovine milk fat.* Food & Nutr Res. 52: epub.

Renaville B, A Mullen, F Moloney, Y Larondelle, YJ Schneider and HM Roche. 2006. *Eicosopentoic acid and 3, 10 dithia stearic acid inhibit the desaturation of trans-vaccenic acid into cis-9, trans-11 conjugated linoleic acid through different pathways in Caco-2 and T84 cells.* Br J Nutr. 95:688-695

Toledo P, A Andren and LJ Björck. 2002. *Composition of raw milk from sustainable production systems.* Int Dairy J. 12:75-80.