UC CE COOPERATIVE EXTENSION
UNIVERSITY OF CALIFORNIA, DAVIS

Mineral Levels in Bulk Milk of California Dairy Cows

P.H. Robinson, T. Beaucaire and D. Meyer

UC Cooperative Extension
Department of Animal Science
University of California, Davis, CA 95616

Introduction

While milk produced by dairy cows is widely recognized for its content of calcium and phosphorous, it also contains appreciable levels of other nutritionally relevant macro and micro minerals. These minerals have importance for a number of reasons, including impacts on human nutrition, impacts on desired mineral levels in the diets of dairy cows and tracking the ultimate fate of minerals consumed by dairy cows in their feed and water. The latter is becoming an issue of substantial importance relative to the environmental impact of dairy cows.

There has been no study reported that measured and reported levels of nutritionally and environmentally important minerals in milk produced by California dairy cows.

Objective

The objective in this study was to determine levels of several minerals in the milk of California dairy cows. In addition, potential relationships between milk mineral levels and the protein and fat content of milk was determined since protein and fat contents of commercial milk samples are routinely reported to dairy producers in California and, if mineral contents of milk are correlated to the fat and/or protein content of milk, this could be an important tool for site specific nutrient management programs on commercial California dairies.

Methods

One bulk milk sample from each of thirty-four dairies was collected during the summer of 2002. These dairies were located in several counties of the Great Central Valley of California. The facilities ranged widely in size, but 31 dairies were Holstein herds.

Before each sample was collected from the bulk tank, the milk was agitated for at least 5 minutes to assure it was completely mixed. Samples were put on ice immediately and

transfered to the nutrition lab at the Department of Animal Science at UC Davis. All samples were stored at –20°C in polypropylene bottles before analysis.

Samples were analyzed for fat and crude protein content by standard wet chemical procedures. The minerals that were analyzed by ICP procedures for calcium, phosphorous, magnesium, potassium, sodium, sulfur, chloride, iron, copper, manganese, zinc, molybdenum and selenium.

Results were evaluated statistically by backward SLS analysis in SAS (1985) with milk fat and protein as predictors and each mineral as the dependent variable. This technique calculating correlation statistics for a model using both predictors, which are deleted from the model until all the remaining predictors are significant at the 15% level.

Results

The concentrations of major and minor mineral elements along with fat and nitrogen in the all the milk samples studied are in the Appendix Table. Milk fat ranged from 2.52 to 4.40% and protein from 2.92 to 3.60%. The variation in milk fat and milk protein among these herds is consistent with the nature of the herds, and the characteristic that 3 of the 31 herds were Jersey herds, which typically have higher milk fat and protein levels than Holstein herds. However, two samples (#16 and # 18) were excluded prior to statistical analysis as outliers (#16 - an unusually high milk fat - 6.04%; #18 – an unusually low milk fat - 2.52%). These values are likely due to incomplete agitation of milk prior to sampling.

Table 1. Correlations between milk fat and/or protein and milk mineral concentrations.

	Equation				*P*		
Mineral	Intercept	Fat (%)	CP (%)	s.e.	Fat	CP	r^2
%							
Ca	203.8	116.14630	124.12187	26.7	.002	.096	.64
P	14.61	----	253.20953	22.9		<.001	.56
Mg	75.19	----	7.76696	2.3		.086	.10
K	1426	----	----	43.0			
S	270.4	----	----	33.5			
Na	383.2	----	----	32.8			
Cl	1242	-96.62837	----	39.4	.009		.22
ppm							
Fe	.3867	.04031	-.11235	.019	.095	.036	.15
Cu	-.0756	----	.04057	.007		.005	.25
Mn	-.0427	-.00522	.02910	.002	.045	<.001	.56
Zn	-3.7923	----	2.55097	.308		.0001	.41
Mo	.0361	----	----	.008			
ppb							
Se	5.23	-10.27023	20.47254	4.81	.081	.123	.11

Table 2 shows the best fit correlations between milk protein and/or fat and each milk mineral examined. Fat or protein levels of milk were included as predictors only if their $P<0.15$. Calcium, phosphorous, manganese and zinc had the highest r^2 values with values of .64, .56, .56 and .41 respectively. Both calcium and manganese were correlated to both milk protein and fat (Figures 1 and 2), while phosphorous and zinc were correlated to only milk protein (Figures 3 and 4). Magnesium, chloride, iron, copper and selenium had at least one statistically significant predictor, but the overall strength of the correlations was much lower (i.e., $.10< r^2<.25$).

Summary

This study has documented levels of several nutritionally and environmentally important minerals in bulk milk from California dairy cows. It has also demonstrated statistically supported relationships between calcium, phosphorous, manganese and zinc, and milk fat and/or protein.

This information will be useful in assessing appropriate feeding levels of minerals in rations of California dairy cows. It will also be useful in predicting mineral levels in milk produced on California dairies utilizing site specific nutrient management programs to track the ultimate fate of minerals consumed by cows in feed and water.

* * * *

P.H. Robinson is a Cooperative Extension Specialist responsible for dairy cattle nutrition and nutritional management. He can be reached at: (530) 754-7565 (voice), (530)752-0172 (fax), phrobinson@ucdavis.edu (e-mail), http://animalscience.ucdavis.edu/faculty/robinson (web).

T. Beaucaire is a responsible for developing a site specific dairy nutrient management model. She can be reached at: (530) 867-3286 (voice), (530)752-0172 (fax), tmbeaucaire@ucdavis.edu (e-mail).

D. Meyer is a Cooperative Extension Specialist responsible for waste management. She can be reached at: (530) 752-9391(voice), (530)752-0172 (fax), dmeyer@ucdavis.edu (e-mail), http://animalscience.ucdavis.edu/faculty/meyer (web).

Figure 1. Relationship between Calcium and Milk Protein and Fat in Cows' Milk

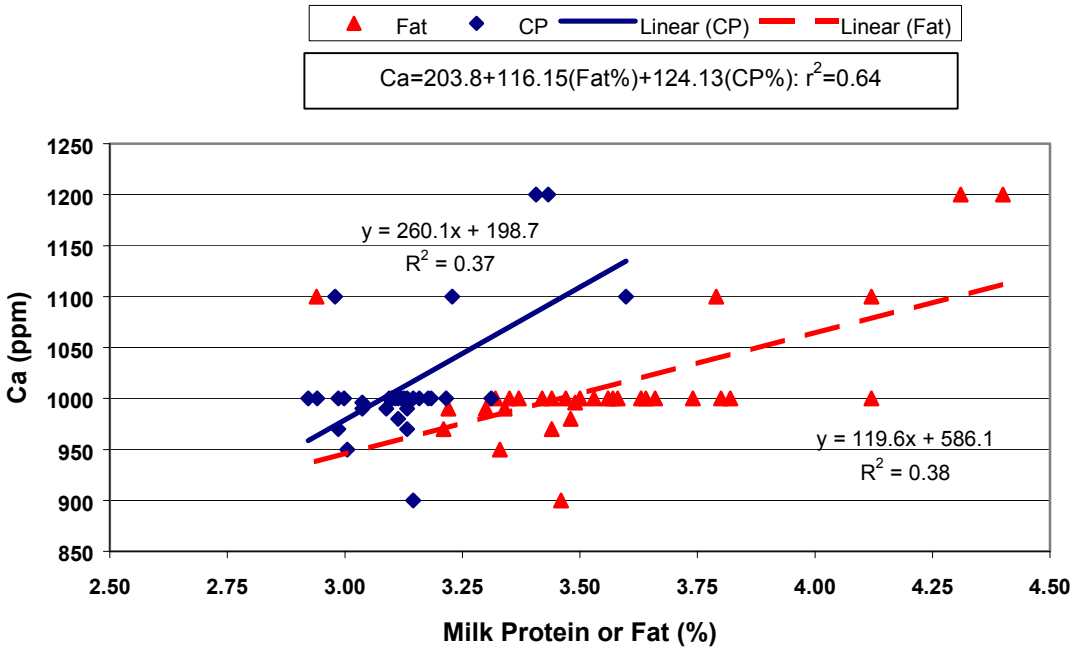


Figure 2. Relationship between Manganese and Milk Protein and Fat in Cows' Milk

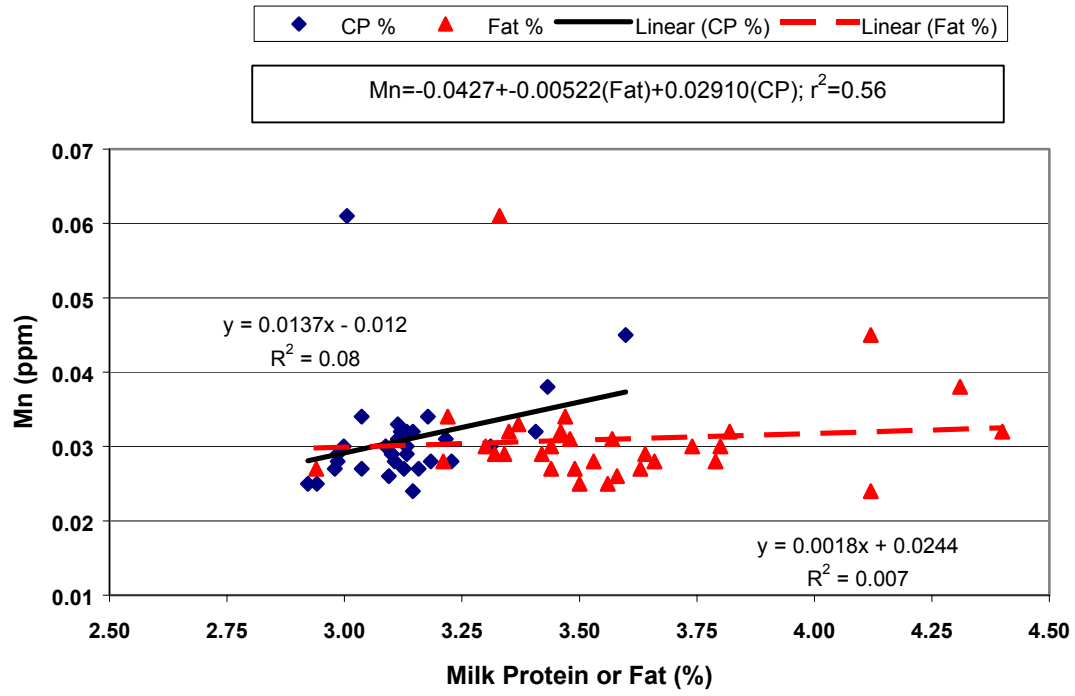


Figure 3. Relationship between Phosphorous and Milk Protein and Fat in Cows' Milk

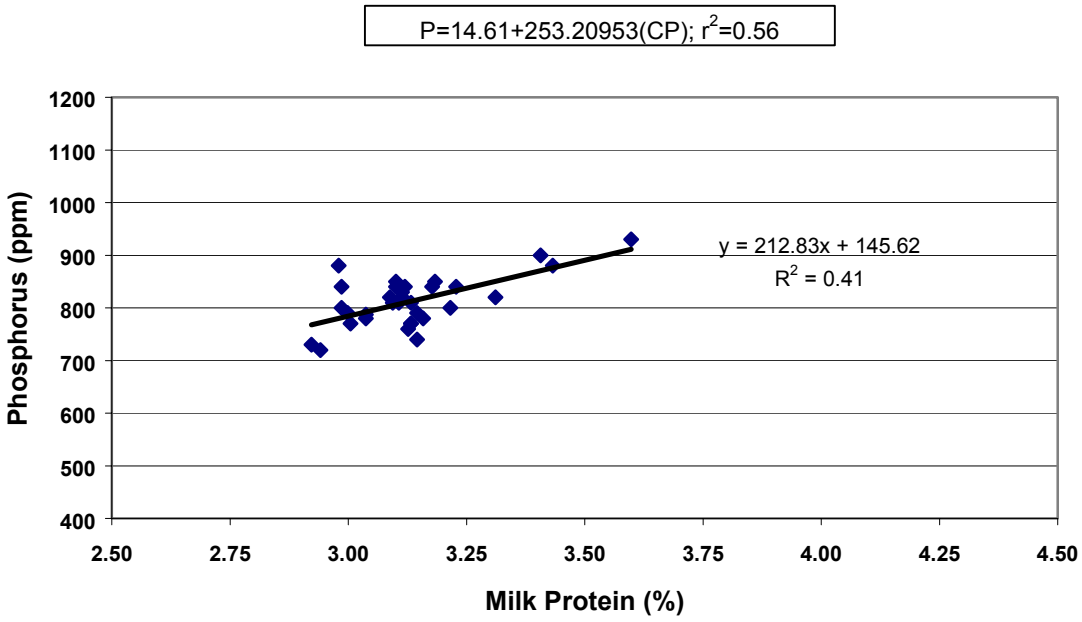
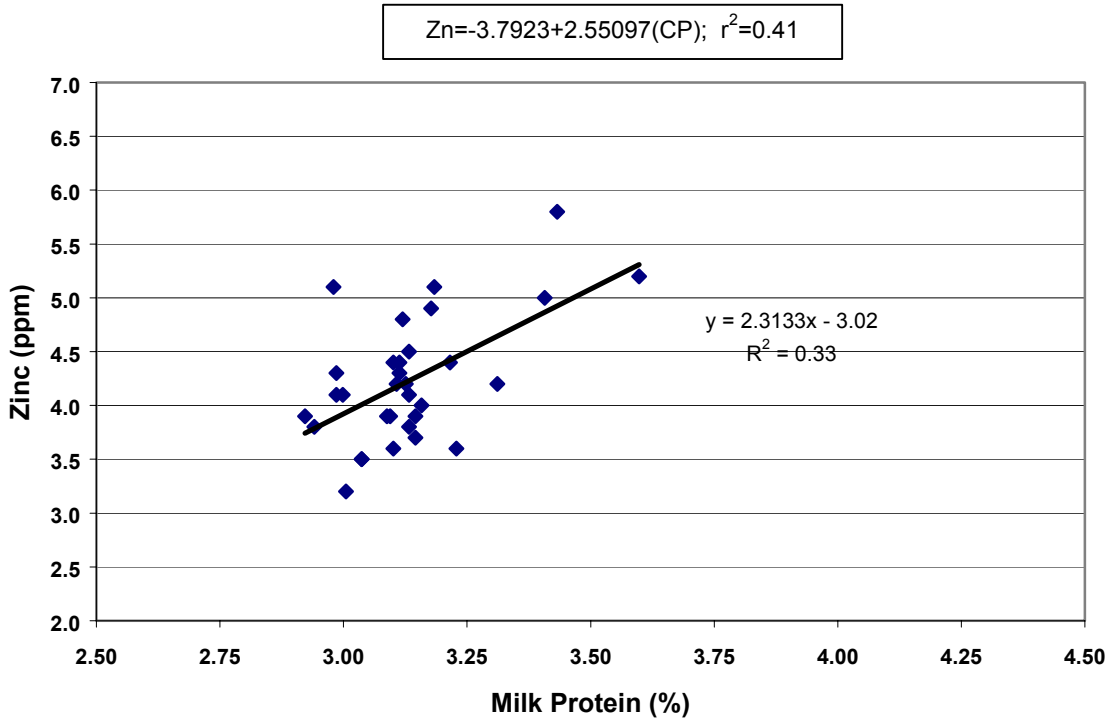


Figure 4. Relationship between Zinc and Milk Protein and Fat in Cows' Milk



Appendix Table. Milk fat, protein and mineral analyses of the individual milk samples.

#	Fat	CP	Ca	P	Mg	K	Na	S	Cl	Fe	Cu	Mn	Zn	Mo	Se
	%	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppb
1	3.46	3.15	900	740	93	1300	390	260	880	0.17	0.065	0.032	3.7	0.041	31
2	3.30	3.09	990	820	98	1400	420	310	880	0.18	0.052	0.030	3.9	<0.02	29
3	4.31	3.43	1200	880	100	1400	380	260	810	0.16	0.067	0.038	5.8	<.025	35
4	3.58	3.09	1000	810	100	1400	410	230	850	0.19	0.048	0.026	3.9	0.041	29
5	3.44	3.13	1000	760	95	1400	400	220	870	0.22	0.054	0.027	4.2	0.027	31
6	3.56	2.92	1000	730	98	1400	380	210	880	0.18	0.048	0.025	3.9	0.040	23
7	3.50	2.94	1000	720	100	1400	470	220	1000	0.16	0.055	0.025	3.8	<.025	32
8	3.57	3.22	1000	800	100	1500	430	220	950	0.20	0.054	0.031	4.4	0.027	37
9	3.80	3.31	1000	820	100	1500	420	250	950	0.17	0.082	0.030	4.2	0.034	35
10	3.44	3.13	970	770	100	1500	420	240	950	0.17	0.063	0.030	4.5	<.025	35
11	3.32	2.99	1000	800	100	1400	360	230	930	0.18	0.042	0.029	4.1	0.029	26
12	3.21	2.99	970	840	100	1500	390	350	890	0.16	0.054	0.028	4.3	0.029	33
13	3.34	3.13	990	770	100	1400	340	270	850	0.17	0.049	0.029	4.1	0.036	24
14	3.53	3.11	1000	810	100	1400	320	390	850	0.18	0.049	0.028	4.2	<0.025	29
15	3.48	3.11	980	820	97	1500	320	280	920	0.18	0.048	0.031	4.4	0.031	32
17	4.40	3.41	1200	900	100	1400	280	340	690	0.14	0.087	0.032	5.0	0.035	31
19	3.22	3.04	990	780	100	1600	320	290	950	0.16	0.038	0.034	3.5	<0.025	26
20	3.49	3.04	996	787	100	1370	336	293	840	0.19	0.047	0.027	3.5	0.039	34
21	3.33	3.00	950	770	96	1400	350	210	930	0.33	0.040	0.061	3.2	0.032	34
22	3.64	3.10	1000	840	100	1400	370	260	870	0.24	0.043	0.029	3.6	0.044	32
23	3.79	3.23	1100	840	97	1400	380	210	900	0.19	0.051	0.028	3.6	0.045	32
24	3.66	3.18	1000	850	95	1500	330	200	910	0.19	0.054	0.028	5.1	0.061	30
25	4.12	3.15	1000	790	100	1500	350	320	880	0.21	0.047	0.024	3.9	0.045	27
26	3.74	3.00	1000	790	100	1400	450	260	1000	0.21	0.037	0.030	4.1	0.050	38
27	3.82	3.13	1000	810	100	1400	420	270	930	0.22	0.050	0.032	3.8	0.058	34
28	3.37	3.11	1000	830	100	1400	420	300	940	0.19	0.050	0.033	4.3	0.059	32
29	3.63	3.16	1000	780	100	1400	410	240	890	0.19	0.040	0.027	4.0	0.041	31
30	4.12	3.60	1100	930	110	1400	430	340	840	0.15	0.052	0.045	5.2	0.042	39
31	3.42	3.10	1000	850	110	1400	370	270	850	0.17	0.051	0.029	4.4	0.032	36
32	3.47	3.18	1000	840	97	1400	420	280	980	0.12	0.044	0.034	4.9	0.036	33
33	2.94	2.98	1100	880	100	1500	330	260	810	0.05	0.048	0.027	5.1	0.033	64
34	3.35	3.12	1000	840	99	1400	360	300	880	0.11	0.043	0.032	4.8	0.041	.
16	6.04	3.54	980	760	91	1600	260	250	920	0.22	0.059	0.034	3.9	0.036	33
18	2.52	3.26	950	830	110	1500	410	380	980	0.17	0.038	0.032	4.3	0.034	33

Notes:

Samples 16 and 18 were rejected as outliers (see text for details).

Samples 3, 17 and 30 are Jersey herds.