Factors Affecting Iodine Concentration of Milk of Individual Cows

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ABSTRACT

Variations were measured of iodine concentrations of milk during complete lactations of 36 Holstein cows from the University of California herd in Davis and 24 Holstein and 12 Guernsey cows from the California State University herd in Fresno. At Davis no iodine was added to the concentrate, whereas at Fresno iodine as ethylene diamine dihydriodide was added to the concentrate at 4 ppm. At Davis, the mean milk iodine concentration was 166 μg/kg; at Fresno, the mean milk iodine concentration was 745 μg/kg. Holstein milk had higher iodine concentrations than Guernsey milk, 839 versus 554 μg/kg. Iodine concentrations of milk increased during lactation for all cows. At Davis, samples taken in the 1st mo of lactation had 105 μg/kg compared with 218 μg/kg in the 9th mo. At Fresno, samples taken in the 2nd wk of lactation had 183 μg/kg, compared with 1017 μg/kg in the 40th wk. Addition of as little as 4 ppm ethylene diamine dihydriodide to the concentrate throughout lactation will lead to greatly increased iodine concentrations in the milk, particularly in late lactation.

INTRODUCTION

The concentration of iodine in milk is nutritionally important. The United States Food and Drug Administration has reported that over 40% of the total dietary iodine intake comes from milk. Kidd (12) reported in 1974 that urine iodine in children was positively correlated with the amount of milk consumed. Various international researchers (6, 10, 11, 13) reported high (200 μg/kg) concentrations of iodine in market milk. Only Binnerts (2) measuring iodine concentrations of market milk in The Netherlands found the concentration of iodine in milk was declining in the last decade.

Iodine is a natural constituent of cows' milk. The cow, in common with other animals, requires a diet that provides nutritionally adequate iodine. Consumed iodine in excess of nutritional requirements is excreted in feces, urine, tears, and milk (9, 14). Positive correlations between iodine intake and milk iodine concentration have been reported by many workers in the past 50 yr (1, 3, 7, 8, 9, 14, 16). However, these reports leave many questions concerning natural variation of iodine concentrations of cows' milk unanswered. Consequently, we have tried, during the last 4 yr (1976 to 1979), to determine what factors affect the concentration of iodine in cows' milk. Our objective was to obtain an understanding of options available to minimize milk iodine concentrations.

MATERIALS AND METHODS

Davis Study

Holstein cows were selected from the University herd as they freshened. The herd was segregated into three groups on milk production: high—30 kg/day; medium—20 kg/day; low—12.5 kg/day. Cows were assigned to groups monthly. All cows were fed 15.9 kg of alfalfa hay per day. Concentrate was fed to the high group at 7.9 kg/day and to the medium and low groups at 3.6 kg/day. All these figures were averages.

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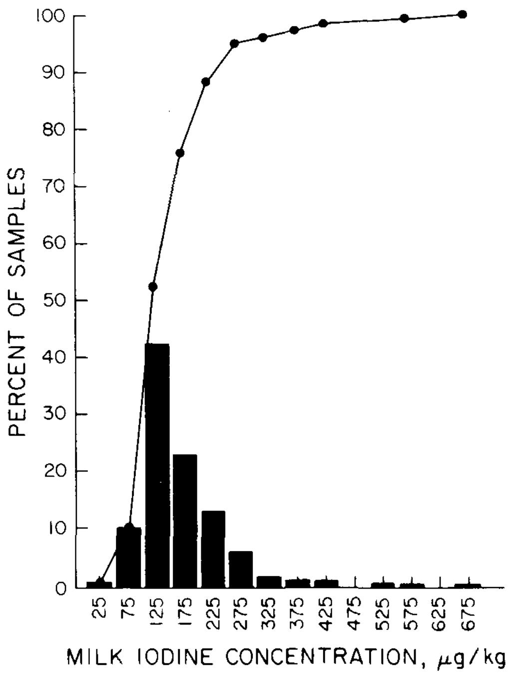

Figure 1. Frequency distribution of iodine concentrations of 213 milk samples collected over entire lactation from 36 cows in the University herd at Davis. Solid curve is cumulative frequency; nearly 90% of the samples were below 200 μg/kg.

Milk samples (ca. 200 ml) were collected once a month for each cow either until she was assigned to another trial (the herd is small, and consequently the research needs of the Animal Science Department took precedence) or completed her lactation.

Fresno Study

Thirty-six cows, 24 Holsteins and 12 Guernseys, in their 1st through 5th wk of lactation were assigned to the trial. The herd was segregated into three groups on milk production: high—29.5 kg/day; medium—18.1 kg/day; and low—11.3 kg/day. Cows were assigned to groups monthly. All cows were fed 13.6 kg of alfalfa hay per day. Concentrate was fed to the high group at 13.6 kg/day, and to medium and low groups at 10.0 and 6.4 kg/day. No adjustments were made for age or breed of cows. Part of the concentrate was fed in the milking barn, and the remainder was fed in pens. Concentrate not consumed in the milking barn was added to that in pens so that weighbacks were not necessary. Iodine as ethylene diamine dihydriodide (EDDI) was added to the concentrate at 4 ppm throughout the trial.

Approximately 170 ml of milk from each cow was frozen and set aside for iodine analyses once a week for the first 12 wk and then once a month to the end of the 40th wk or until 60 days before calving, whichever came first.

Analyses

Milk iodine concentrations were measured by the selective ion electrode procedure (4, 5).

All statistical analyses were by the eighth release of SPSS (15) and the campus B 6700.

RESULTS AND DISCUSSION

Davis Study

The frequency distribution of milk iodine concentrations in 213 samples for 36 cows (Figure 1) was slightly skewed. The median was 146 μg/kg, and the mean was 166 μg/kg with a standard deviation of 83 μg/kg. These are indicative of milk iodine concentrations that can be expected when extraneous sources of dietary iodine (EDDI, trace mineralized salt, etc.) are eliminated and when the use of iodophor containing udder washes and teat dips are controlled rigorously.

Of the 213 samples collected, 159 were provided by 19 cows. Data for this subgroup were classified by animals, lactation stage, and time of year, and analyzed by classical analysis of variance. Results (Table 1) show

TABLE 1. Extremes of iodine concentrations of milk in the Davis study; no supplemental iodine in concentrate.

	Milk iodine concentration			
	High		Low	
Variable	$\bar{X}$	SD	$\bar{X}$	SD
	(μg/kg)			
Animals	209	44	111	32
Lactation stage	9th month		1st month	
	218	58	105	29
	May		February	
Time of year	202	75	132	36

that there were large variations of iodine concentrations. Samples collected later in lactation had higher iodine concentrations than those in early lactation. Concentrations were higher in May than in February, the other 10 mo falling between. The analysis of variance (Table 2) indicated that these three classifications accounted for 60% of the variation of iodine concentration of milk.

Fresno Study

Frequency distributions of iodine concentrations of milk from two breeds of cows and two age groups within breeds (Figure 2) illustrate differences between breeds and between age groups within breed. During the trial all cows were fed a concentrate supplemented with 4 ppm iodine as EDDI, which was 40% of the maximum amount recommended by the National Research Council when this study was done (1978).

Comparison of iodine concentrations of milk for the Fresno cows (Table 3) with those of the Davis cows (Table 1) shows the effect of constant supplementation of 4 ppm EDDI in concentrate of Fresno cows throughout lactation. The mean for the multiparous Holsteins at Fresno (736 μg/kg) is 4.4 times the mean (166 μg/kg) for Holsteins at Davis. The highest iodine concentration at Davis was 675 μg/kg, which is less than the mean at Fresno.

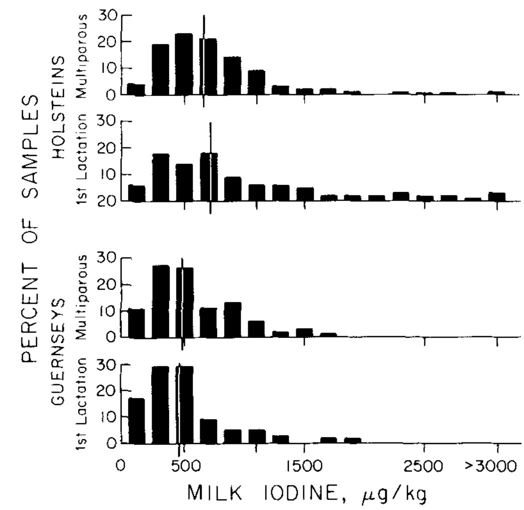

Figure 2. Frequency distribution of iodine concentration in milk samples collected from cows fed concentrate supplemented with 4 ppm iodine during entire lactations in the University herd at Fresno. Vertical lines show median concentration.

Increases of iodine concentrations of milk at Fresno during lactation (Figure 3) were greatest for uniparous Holsteins and followed the same general trend for all four groups. Iodine concentrations increased gradually during the first 25 wk of lactation, then jumped by a factor of

TABLE 2. Results of three way analysis of variance on iodine concentrations of milk in the Davis study; no supplemental iodine in concentrate.

Source	Proportion of variation accounted for
Animals	23%
Lactation stage	27%
Time of year	10%

TABLE 3. Iodine concentrations of milk for cows in the Fresno iodine trial.

Breed	Lactations	No. of samples	Milk iodine $\bar{X}$	SD
			(μg/kg)	
All cows		481	745	604
All Guernseys		158	554	364
Guernseys	1	65	509	371
Guernseys	2 or more	93	585	358
All Holsteins		323	839	672
Holsteins	1	124	1004	850
Holsteins	2 or more	199	736	508

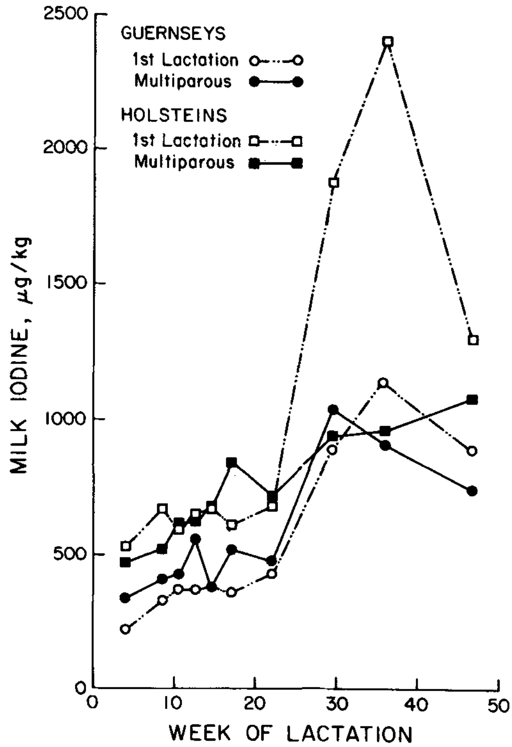

Figure 3. Relationship between week of lactation and milk iodine concentration for cows fed concentrate supplemented with 4 ppm iodine throughout lactation in the University herd in Fresno.

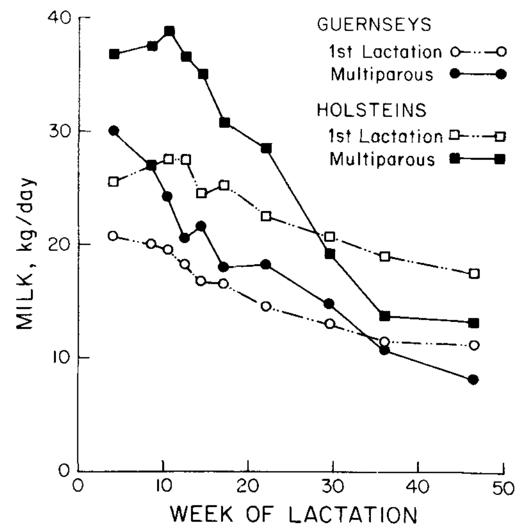

Figure 4. Relationship between week of lactation and milk production for cows in the University herd at Fresno.

4 or more for Guernseys and uniparous Holsteins. Increases for multiparous Holsteins were more uniform throughout lactation. These increases probably were related to the continual feeding of EDDI to the cows during the study (1, 3, 7, 8, 9, 10, 14, 16).

Data for each group of cows were analyzed to partition variation of iodine concentration among animals, lactation stages, and interactions between the two (Table 4). Guernseys and uniparous Holsteins were relatively similar; 7 to 12% of the variation was accounted for by differences among animals, 51 to 63% by lactation stage, and 28 to 35% by interactions. Multiparous Holsteins were different from the other three groups; differences among animals accounted for 28% of the variation, lactation stage for 13%, and interactions for 55%.

At first, we thought differences of iodine concentrations among the four groups of cows might be related to milk production, but the

TABLE 4. Partitioning of variation of iodine concentration of milk between animals and lactation stage within breed by age in Fresno trial.

Breed	Lactation	Proportion by variation accounted for by		
		Animals	Lactation stage	Interaction
		(%)		
Guernsey	1	7	63	28
	2 or more	12	51	35
Holsteins	1	12	55	30
	2 or more	28	13	55

data (Figure 4) indicate otherwise. The group (uniparous Holsteins) with the highest iodine concentrations of milk in late lactation also had the highest daily milk production in late lactation. Lactation mean daily iodine intakes from concentrate were 32 mg for uniparous Guernseys, 39 for multiparous Guernseys, 40 for uniparous Holsteins, and 46 for multiparous Holsteins. Based on amounts of concentrate consumed, iodine intakes decreased as lactation progressed, but multiparous Guernseys and uniparous Holsteins still were getting more than 30 mg of iodine from this source even at the end of lactation.

Hemken et al. (8) fed 6.8 or 68.0 mg of supplemental iodine as potassium iodide in 5 ml of water once daily on top of the concentrates for 12 wk starting in the 7th to 11th wk following calving and found milk iodine concentrations of 81 (range 51 to 124) and 694 (range 608 to 870) μg/liter. Considering that exposure in the Fresno trial was 40 wk, it is reasonable that supplemental iodine ranging from 32.0 to 46.5 mg per day would result in the concentrations observed.

Hillman and Curtis (9), working with two groups of 45 Holstein cows that were fed "normal" (16 mg per day) or "high" (164 mg per day) iodide, found iodine concentrations of milk of 370 and 2160 μg/liter. Their "high" group was distributed among five herds being given EDDI for prophylactic purposes, and because it contained equal numbers of cows in the first, second, and last third of lactation, probably gave a good estimate of iodine concentrations of milk for lactations for cows exposed to this supplemental iodine. Their "normal" group gave milk with nearly five times the iodine concentration (370 vs. 81 μg/liter) when fed only three times as much supplemental iodine (16 vs. 6.8 mg/day). These results are also consistent with ours.

CONCLUSION

The objective of these studies was to obtain an understanding of factors affecting iodine concentrations of milk.

At Davis, differences among animals and differences due to lactation stage accounted together for half the variation of iodine concentration of milk.

At Fresno, where the iodine concentrate was maintained at a constant 4 ppm supplementation, breed differences for iodine concentrations of milk were important. Also, among Guernseys and uniparous Holsteins, effects of lactation stage accounted for more than half the variation of iodine concentration of milk, whereas for multiparous Holsteins they accounted for only about one-eighth.

Breed differences, although significant, cannot be used to control iodine concentrations of milk. In regions where dairying is year-round, effects of lactation stage can be minimized by having cows freshen in equal numbers during each month of the year.

Finally, the most significant single factor within the dairy farmer's ability to control the iodine concentration of milk is the iodine concentrations of the concentrate fed to the cows. When no iodine is added to the concentrate and iodophors are used responsibly at the dairy farm, Holstein cows will produce milk with iodine concentrations of less than 200 μg/kg.

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