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Effect of iodine supplementation on milk iodine concentrations and productivity of dairy cows

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ABSTRACT

Iodine (I) concentrations in New Zealand pastures are low and may be inadequate to meet the I requirements of lactating dairy cows. A trial was undertaken with 400 cows to determine the effects of a single intra-muscular injection of 2000 mg I (in popyseed oil) given at the beginning of lactation on cow performance. The pasture I concentration ranged between 0.17-0.26 mg I/kg DM during of the trial and the supplement increased serum thyroxine (T_4) and milk I concentrations for 76 ($P<0.05$) and 170 ($P<0.01$) days respectively. Iodine supplementation did not affect milk yield milk composition or number of services per conception. To increase I status and maintain milk I concentrations at or above 40 µg/l, that is at a concentration twice that of untreated cows, 2000 mg I would need to be injected at 6 month intervals.

Keywords: dairy cows; I supplementation; serum thyroid hormones; milk I; milk yields; reproductive performance.

INTRODUCTION

Iodine deficiency was endemic in the human population in New Zealand prior to the introduction of iodised salt, and signs of I deficiency were common in sheep and cattle in some areas. The deficiency is characterised by a decrease in the synthesis and secretion of the thyroid hormones, thyroxine and triiodothyronine, which have a marked effect on metabolic rate and cell differentiation (Canzanelli *et al.*, 1939, Ferguson *et al.*, 1965, Erenberg *et al.*, 1974). Signs of I deficiency are an enlarged thyroid or goitre, impaired reproductive performance, high perinatal mortality, lowered milk yields and reduced wool growth (Sinclair and Andrews, 1958).

Iodine status and requirements of livestock have been assessed by measurement of milk I concentrations and by relating animal performance to daily thyroid secretion rate (Henneman *et al.*, 1955, Premachandra *et al.*, 1958, Alderman and Stranks 1967). However dietary I requirements for cattle are ill defined with estimates varying from 0.12 to 0.84 mg I/kg DM for a goitrogen free diet. The recommended value is 0.5 mg I/kg DM although there is evidence that in some situations concentrations of 0.15 mg I/kg DM could be adequate (Agricultural Research Council 1980). Many New Zealand pastures contain less than 0.25 mg I/kg DM (Barry *et al.*, 1983) but there have been no studies to determine whether this provides an adequate I intake particularly for dairy cattle.

This investigation was designed to study the effect of supplementary I on the I status of grazing dairy cows as indicated by serum thyroid hormones and milk I concentrations, as well as milk yields, milk composition and reproductive performance.

MATERIAL AND METHODS

Animals and Design

The study was carried out with a 400 cow Friesian herd grazing predominantly ryegrass/white clover pastures with low I concentrations at the Flock House Research Centre, near Bulls. The cows were divided into two groups on the basis of age, calving date and production performance and one group was given an intramuscular injection of 5 ml of iodised oil (2000 mg I) in mid August 1993. Calving commenced in early July and both groups were grazed and managed as one herd and all cows were given two 30 g intraruminal boluses containing 3 g Se and 20g CuO needles 3 months prior to the experiment because pastures were known to be low in Se (0.02 mg/kg DM) and Cu (5 mg/kg DM).

Collection of samples

Pasture samples were collected at 2-weekly intervals and bulked within months for the duration of the trial to determine I concentrations. Blood samples were taken from 40 cows in each group to monitor changes in serum thyroxine (T_4) and triiodothyronine (T_3) concentrations prior to iodine injection in August 1993. Milk (50 ml) was collected from the same animals, so that both milk and blood samples were collected in September, December 1993, January, March and April 1994. On each occasion milk was sampled from the hind quarters by hand before the cows were machine milked after which blood was taken from the tail vein using a vacutainer and the serum obtained by centrifugation (2000 g for 20 minutes). Care was taken to prevent I contamination from external sources by acid washing all containers for milk collection; iodophors were not used to clean the dairy equipment and no I- containing remedies or dietary supplements were given to cows. The

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remaining 160 cows in each treatment were used to monitor milk production and composition from herd testing data, and number of services per conception.

Analytical

Iodine I concentration in the pasture and milk were determined after an alkaline ashing by an oxidation-reduction reaction (Sandell-Kolthoff reaction) between Ce (IV) and (AsIII) as described by Azuolas and Caple (1984). The T_4 and T_3 were measured in serum using a radioimmunoassay (Miller and Albyt 1985).

Statistical Analysis

Analysis of variance was used to determine the significance of differences between treatments for both the subgroups providing blood and milk data and the entire herd for milk production and reproductive performance. Data are presented as means with standard errors.

RESULTS

The pasture I concentrations range from 0.17 to 0.26 mg I/kg DM with the lowest concentrations occurring in the summer. The mean serum T_4 and T_3 concentrations prior to treatment were 57.1 and 2.16 nmol/l respectively. The I injection did not affect T_3 concentration during the trial, but increased serum T_4 concentration ($P<0.05$) to day 76. While milk I concentration was significantly elevated ($P<0.01$) through to day 170 of the study (Table 1). Iodine supplementation had no effect on milk yield, milk composition or on reproductive performance (Table 2). Over 90% of cows were in calf after two matings.

DISCUSSION

The main findings from this trial were that a single 2000 mg iodine injection increased milk I concentration by a substantially for 6 months. In contrast, an increase in the thyroxine concentrations was evident for only half this period. The absence of effects on milk yield, milk fat or protein content and on reproductive performance suggests that pastures containing 0.17 to 0.26 mg I/kg DM are adequate for dairy cows producing less than 4000 kg milk per lactation.

The pasture I concentrations observed were similar to those reported for other pastures in New Zealand (0.1 to 0.27 mg I/kg DM; Barry *et al.*, 1983) and the United Kingdom (0.22 to 0.32 mg I/kg DM; Alderman and Jones 1967). Iodine supplementation increases the I content of the thyroid, which contains 70-80% of the body I (Hetzel and Maberly 1986) and increases the concentration of T_4 in the serum (Parker and McCutcheon 1989) especially in I deficient animals. Assessing the I status of livestock from serum-T_4 concentrations is difficult because neuro-endocrine factors regulate the thyroid activity. The synthesis and secretion of the thyroid hormones is influenced by thyroid stimulating hormone (TSH) from the pituary and thyrotropic releasing hormone (TRH) from the hypothalmus (Sterling and Lazarus 1977). For example during very cold weather the secretion of TSH and thyroid hormones is increased to stimulate basal metabolism in order to maintain body temperature (Freake and Oppenheimer 1995). Changes in milk I concentrations also reflect I intakes and I status (Azuolas and Caple 1984). In sheep milk I concentrations of 15 µg/l were associated with severe goitre in suckling lambs while no goitre was observed with milk containing 80 µg I/l (Mason

TABLE 2: Effect of I supplementation on milk yield, milk composition and reproduction performance of grazing dairy cows. Data are means ± standard error. n=200.

	Milk Yield l	Days in Milk	Fat production kg	Protein production kg
No Iodine	3728±55.6	243±5.3	186±4.5	142±3.3
Iodine	3584±71.2	240±6.6	184±6.2	139±4.3
Percent of cows conceiving				
Mating number	1	2	3	4
No Iodine	70	22	5.6	1.7
Iodine	60	31	6.3	3.5

TABLE 1: Effect of I supplementation on serum thyroxine (T_4), triiodothyronine (T_3) and milk I concentrations in grazing dairy cows. Data are means ± standard error. n=40.

	Days after injection					
	0	35	76	120	170	210
Serum T_4 (nmol/l)[1]						
No Iodine	56.3±2.35	51.7±2.46^a	47.4±1.67^a	53.9±1.92	43.4±2.59	48.8±1.37
Iodine	57.9±2.74	64.6±2.24^b	59.6±2.74^b	57.9±1.88	48.6±2.51	49.6±1.47
Serum T_3 (nmol/l)						
No Iodine	2.12±0.078	2.31±0.074	2.09±0.050	2.11±0.055	1.84±0.044	1.88±0.037
Iodine	2.21±0.081	2.22±0.069	2.03±0.050	1.99±0.054	1.89±0.057	1.77±0.059
Milk I (µg/l)[2]						
No Iodine	-	< 20^A	< 20^A	< 20^A	< 20^A	< 20
Iodine	-	75±10.2^B	92±12.0^B	44±5.8^B	49±9.5^B	< 20

[1] for each measurement, within a column means with different superscripts are significantly different avb (P<0.05); AvB (P<0.01).

[2] detection limit for milk I <20 µg/l.

1976). A significant relationship y=2.13x + 3.1 (R^2 = 0.79) between milk I concentrations (6-31 µg/l) (y) and daily milk I intakes (3.1-14.3 mg/day) (x) has also been reported for dairy cows (Alderman and Stranks 1967).

Given that an injection of 2000 mg I increased and maintained milk I concentrations of 92 µg/l at day 76 and 49 µg/l at day 170 means that infants and children consuming daily 0.5 to 1 litre of milk from I treated cows could meet most of their I requirements of 50 to 90 µg/day (National Academy of Sciences 1980) and therefore counter the reduced intakes of I associated with the general recommendations to decrease intakes of (iodised) salt.

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